BITE FORCE MEASUREMENTS IN PATIENTS TREATED FOR MANDIBULAR FRACTURES

A THESIS SUBMITTED TO THE BABA FARID UNIVERSITY OF HEALTH SCIENCES, FARIDKOT (PUNJAB)

FOR THE AWARD OF DEGREE OF

MASTER OF CHIRURGIAE

IN

PLASTIC SURGERY

BY

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Dedicated

to

my Family

&

Teachers

ACKNOWLEDGEMENT

The journey through this thought provocative, educative, informative enterprising novel work has enriched me with immense knowledge and experience. As this work is successfully reaching its culmination I look back at the entire work and find it to be well supported and blessed by many.

Amongst all, most noticeable was the support of my chief supervisor ***Prof Sanjeev Kumar Uppal****, Head, Department of Plastic Surgery, Dayanand Medical College and Hospital, Ludhiana, a foundation of knowledge whose guidance has proved invaluable. His pearls of wisdom coupled with valuable criticism have contributed largely in my way to the completion of this work. His emphasis on punctuality, perseverance and being systematic has helped me in improving myself constantly. Apart from being my mentor and guide he has always been a sire figure for me. I stand indebted to him for his motivation, support, encouragement and affection that he has bestowed upon me.*

I wish to place on record my indebtedness and express my humble gratitude to my esteemed mentor ***Prof. Rajinder Kumar Mittal****, Professor, Department of Plastic Surgery, Dayanand Medical College and Hospital, Ludhiana, for his diligent efforts in providing the practical tips to tackle complicated situations with limited resources. Without his substantial supervision, affectionate encouragement, sincere criticism and meticulous attention to details despite his overworked schedule, it would have been impossible for the present work to have taken this form.*

Words are inadequate to express the depth of my gratitude for my revered teacher and co-guide ***Prof. Ramneesh Garg*** *Department of Plastic Surgery, Dayanand Medical College and Hospital, Ludhiana for his cooperation, constructive suggestions, encouragement right from the very beginning helped me*

to complete this work. He taught me to make dreams come true through five D's- Direction, dedication, determination, discipline, deadline, whose ever presence in my mind with helping attitude, helped me to complete this work.

Words are inadequate to express my gratitude for ***Dr Sheerin Shah,*** *Associate Professor, Department of Plastic Surgery, Dayanand Medical College and Hospital, Ludhiana, for her cooperation, constructive suggestions, encouragement and moral support right from the very beginning which helped me to complete this work.*

I am thankful to ***Dr Sandeep Puri ,*** *Principal, Dayanand Medical College and Hospital, Ludhiana, and* ***Dr G S Wander,*** *vice Principal, Dayanand Medical College and Hospital, Ludhiana ,for their time to time help, guidance and suggestions.*

I also like to thank ***Mr Praveen Bhatia, Namita Bansal*** *for their statistical help, advise, and support throughout the course of this study.*

It is indeed a great pleasure to put on record my profound sense of gratitude and indebtedness to ***Prof Sunil Katyal,*** *Professor and Head, Department of Anaesthesiology and Critical Care, Dayanand Medical College and Hospital, Ludhiana, and his team of Anaesthetists including* ***Dr. Pramod Sood , Dr. Anju Garewal , Dr. Suneet Kathuria, Dr Rupinder Kaur, Dr Shikha Gupta, Dr. Richa Jain, Dr Namrata, Dr Kamakshi, Dr Udeyana Singh and Dr Tanveer Singh***

I must say that a task such as this would not have been easy without the help and practical suggestions of my seniors ***Dr. Vikas Jain, Dr. Karan Bakshish Singh, Dr. Bhavya Thakur, Dr. Maninder Kaur,*** *and my colleague* ***Dr. Gaurav Bhatia*** *and juniors* ***Dr. Tushar Patial , Dr. Amandeep Kaur , Dr.***

Karan Singh , Dr. Devika Rakesh , *for their advice, support and cooperation which has helped to a great extent.*

At this juncture I would like to express my heartfelt thanks to my parents ***Dr. Mohd. Rafique*** *and* ***Dr. Shabana Rafique*** *and my better half* ***Dr. Hina Ali*** *, my sister* ***Dr. Saima Rafique*** *without their love and support it would not have been possible for me to put my efforts in this work.*

I am thankful to ***Mr. Harish Chander, Mr. Rajkumar, Mr Brahm Avtar, Mr Brahm Dutt, Mr Kishan*** *and all the Out Patient and O.T. staff of Department of Plastic Surgery, Dayanand Medical College and Hospital, Ludhiana,*

I am thankful to ***Mr. Sushil & Mr. Jaspal Negi*** *for their tireless prompt work in processing this manuscript.*

In the end again I am thankful to ***Almighty****, for blessing me and for showering immeasurable blessings and showing me the right path to follow.*

Dr. Soheb Rafique

ABBREVIATIONS

ORIF- Open reduction and internal fixation

MMF- Maxillo mandibular fixation

VAS- visual analogue scale

SSI- surgical site infection

AO- Arbeitsgemeinschaft fur osteosynthesefragen

ASIF- Association for study of internal fixation

EMG- Electro myo graphy

LCP- Locking compression plates

DCP- Dynamic compression plates

THORP- Titanium Hollow-Screw Reconstruction Plate

ABSTRACT

Introduction: Fracture of mandible is a common condition which is increasing in incidence in the trauma centers due to increasing motor vehicles and failure to abide by traffic regulations and precautionary methods. Patients undergo surgical open reduction and internal fixation where post operative occlusion and normal masticatory functions are targeted. Bite force can be taken as a guide of normal masticatory function of an individual which is dependent upon craniomandibular biomechanics.

Aim: Aim of this study is to compare bite force measurements in patients who underwent open reduction and internal fixation for different types of isolated mandible fractures at 2, 4 and 6 weeks postoperatively who met the inclusion criteria.

Materials and methods: Molar bite force was recorded in 31 post operative patients who underwent open surgical procedure in the department of Plastic Surgery from January 2018 to June 2019 was done by a prescale bite force recorder- Nupai Bite force prescale system (FUJI^{TM}) . Various parameters were recorded pre and post operatively including age, gender, history, comorbidities, requirement of MMF, site, number of fractures and age of injury. Bite forces were compared and improvement of bite force every 2 weeks was noted and analysed upto 6 weeks postoperatively.

Results: Bite force improvement was seen in all types of mandible fractures irrespective of the site and type of fractures over a period of 2nd, 4th and 6th week post operatively. This improvement was however not statistically significant. Decresed time of injury to surgery resulted in improved bite force measurements. This improvement too was not statistically significant.

Conclusion: A more extensive study over a longer duration of time that would include more study subjects and which may include more number of variables would have more statistical significance.

Keywords: Bite, Mandible, Reduction, Fixation, Occlusion

TABLE OF CONTENTS

S. NO.	TOPIC	PAGE NO
I	INTRODUCTION	1-3
II	AIMS AND OBJECTIVES	4
III	REVIEW OF LITERATURE	5-45
IV	MATERIALS AND METHODS	46-53
V	OBSERVATIONS AND RESULTS	52-79
VI	DISCUSSION	80-84
VII	SUMMARY & CONCLUSION	85
VIII	BIBLIOGRAPHY	86-94
IX	APPENDICES – I	
	- PROFORMA	
	- MASTER CHART	
	APPENDICES – II	
	- APPROVAL LETTER OF THESIS PLAN	
	- THESIS PLAN	

LIST OF TABLES

Table. No.	Title	Page No.
1.	Age distribution of patients	54
2	Distribution according to sex	55
3	Distribution according to the mode of injury	56
4	History of oral bleed	56
5	Associated comorbidities	57
6	Presence of mandibular mobility	58
7	Number of fractures	59
8	Types of fratures	60
9	Site of fracture	61
10	Time duration from the date of injury to date of surgery	62
11	Approach for the surgical procedure	63
12	Plating method	64
13	Post operative maxillomandibular fixation	65
14	Post operative pain (VAS score)	66
15	Post operative chewing ability (VAS score 0-10 in increasing order of normal bite function)	67
16	Post operative complications	68
17	Correlation between various factors and post op bite force	69
18	Correlation between number of fractures and post op bite force	70
19	Correlation between injury to surgery interval and post op bite force	73
20	Parasymphysis fracture and post op bite force recovery	76
21	Body of mandible fracture – improvement in bite force	77

22	Angle of mandible fractures compared in improvement of bite force	78
23	Subcondylar fractures and bite force improvement	79

LIST OF FIGURES

Fig. No.	Title	Page No.
1	Age distribution of patients	54
2	Distribution according to sex	55
3	Distribution of history of oral bleed	56
4	Associated co-morbidities	57
5	Distribution of mandiblar mobility	58
6	Distribution of number of fractures	59
7	Distribution of the types of fractures	60
8	Distribution of the anatomical site of fracture	61
9	Duration from date of injury to surgery	62
10	Distribution of surgical approach for ORIF	63
11	Distribution of post operative maxillomandibular fixation	65
12	Distribution of pain according to VAS score post operatively	66
13	Post operative chewing ability (VAS score 0-10 in increasing order of normal bite function)	67
14	Distribution of post operative complications	68
15	Correlation between number of fractures and Difference at 4 week Rt	71
16	Correlation between number of fractures and Difference at 4week Lt	71
17	Correlation between number of fractures and Difference at 6week Rt	72
18	Correlation between number of fractures and Difference at 6week lt	72
19	Correlation between injury to surgery interval and Difference at 4week Rt	74
20	Correlation between injury to surgery interval and Difference at 4week lt	74

21	Correlation between injury to surgery interval and Difference at 6week Rt	75
22	Correlation between injury to surgery interval and Difference at 6week lt	75
23	Parasymphysis fracture and post op bite force recovery	76
24	Body of mandible fracture – improvement in bite force	77
25	Angle of mandible fractures compared in improvement of bite force	78
26	Subcondylar fractures and bite force improvement	79

INTRODUCTION

Bite force is one indicator of the functional state of the masticatory system that results from the action of jaw elevator muscles modified by the craniomandibular biomechanics.[1] Determination of individual bite force level has been widely used, mainly to understand the mechanics of mastication. In addition, bite force has been considered important in the diagnosis of the disturbances of the masticaory system.[2]

The major determinants of masticatory function are the range of mandibular motion, occlusion, maximum occlusal forces, and the activity of masticatory muscles.[3] This function is altered in dentofacial abnormalities and in traumatic and pathological injuries to the jaws. The measurement of bite force can provide useful data for the evaluation of jaw muscle function and activity.

The ever increasing pace of modern life with high-speed travel as well as an increased violence and intolerance in society has made facial trauma quite common in trauma centres. Besides road traffic accident and violence, direct/indirect trauma may also occur due to sport activities, falls, and firearms. Alcohol consumption is a well-known contributing factor to mandibular fractures derived from assault or road traffic acidents.

Fracture is defined as “breach in the continuity of bone”.[4] Mandibular fractures are the second, most-frequent facial injuries treated at a trauma centre. According to several studies, they account for 36% to 70% of all facial fractures.[5,6] Fractures of the mandible not only cause a change in the skeletal architecture but also lead to changes in the other components of the masticatory apparatus in the form of masticatory muscle tear or injury and neurovascular injuries. Surgical treatment of mandibular fractures aims at restoration of skeletal form of the mandible with a hope that normal function and esthetics would be restored.

Fractures of mandible invariably produce malocclusion if not treated properly. Knowledge of the dentition is thus an absolute prerequisite for

the proper treatment of jaw fractures. Various techniques that are advocated in the literature to manage mandibular fractures vary ranging from bandages and external appliances, extra oral and intraoral appliances, mono maxillary wiring, intermaxillary wiring, plates and screws. Restoration of the occlusion usually indicates anatomic reduction and proper positioning of the mandible and facial bones. Our goal should be restoration of the function without any morbidity at the earliest.

Guglielmo Salicetti[7] in 1492 introduced the concept of maxillomandibular fixation, which was later popularized by Gilmer[8] in 1887. The concept of open reduction for fractures of the mandible was introduced by Buck[9] using an iron loop, followed by Gilmer[10] and Luhr.[11] Champy et al described a novel and currently the most accepted concept of using noncompression monocortical plates in the regions, referred to as ‘‘Champy’s lines of osteosynthesis’’.[12]

Several factors influence the direct measurements of the bite force. Thus, different investigators have found a wide range of maximum bite force values. The great variation in bite force values depends on many factors related to the anatomical and physiologic characteristics of the subjects. accuracy and precision of the bite force levels are affected by the mechanical characteristics of the bite force recording system[13] When the ramus is more vertical and the gonial angle acute, elevator muscles exhibit greater mechanical advantage[14] Pereira et al[15] have found a negative correlation between bite force and mandibular inclination

Farella et al[16] have stated that masseter muscles are thicker in shortfaced subjects than in normal or long-faced subjects. From the results of these studies, it seems that short-faced people may exhibit stronger bite force.

The concern on the intraoral force has a long history[17] In the related research, a wide range of methods and devices for the determination of bite forces has been reported. These devices vary from simple springs to complex electronic devices Today, sensitive electronic

devices are used. Such instruments are both accurate and precise enough for common load measuring.

Keeping in view the perceived benefits of bite force measurements on occlusion as well as patient satisfaction during post op recovery, it is essential that evidence in support of this should be substantiated and its feasibility and applicability in clinical situations should be validated. Hence, the present study was proposed to evaluate the post operative bite forces in patients who were treated for different types of mandibular fractures.

AIM AND OBJECTIVE

The present study was carried out with an aim to study the bite force measurements in patients treated for mandibular fractures

This aim was fulfilled with the help of following objective:

1. To assess and compare the bite force generated in post operative patients who underwent open reduction and internal fixation for different types of mandible fractures.

REVIEW OF LITERTURE

ANATOMY

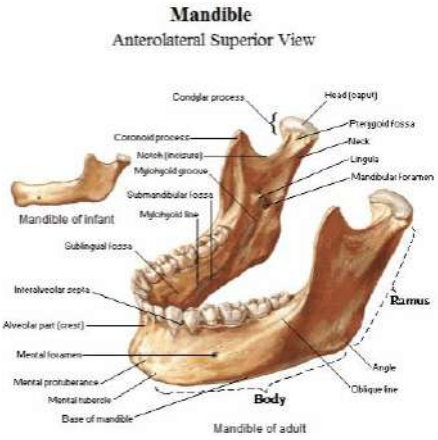
Mandible bone is U shaped and it is composed of two hemi mandible which fuse to form a single bone at the age of two years. It is a first pharyngeal arch derivative.

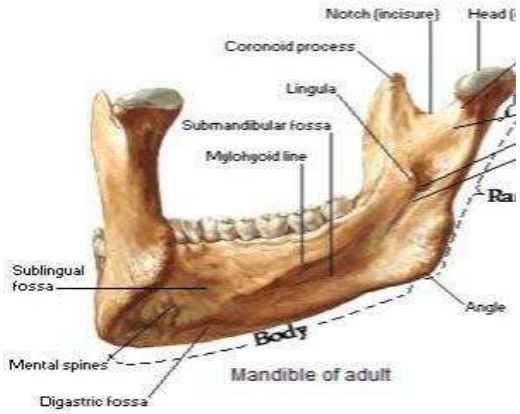
Parts of mandible

Hemi mandible consist of Parasymphysis, body, angle, Ramus, Condyle and Coronoid process united in the midline by Symphysis. (Fig.1, 2).

Fig. 1 **Fig. 2**

Mandible left posterior view





Parasymphysis

It extends from midline to canine region.

Body of the mandible

It has upper and lower border and an inner and outer surface.

Outer surface of body

Symphysis menti - a ridge where the two body meet.

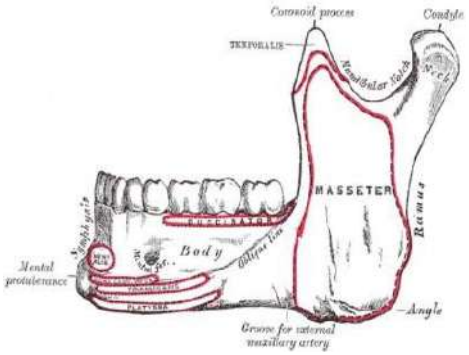
Mental protuberance - triangular projecting area in the lower part of midline.

Mental foramen - it lies in the interval between the premolar teeth which transmits mental nerve and vessels.

Oblique line - continuation of sharp anterior border of Ramus. Buccinator, depressor labii inferioris and depressor anguli oris arise from the line.

OUTER SURFACE OF MANDIBLE

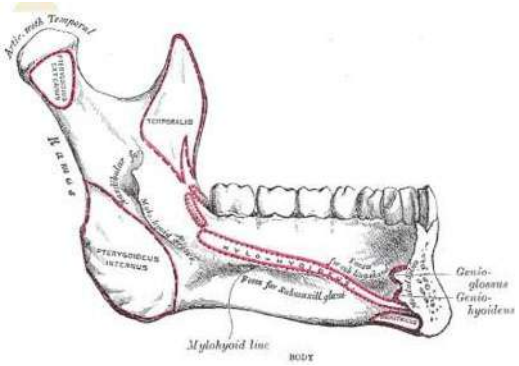
Fig .3



Incisive fossa - it is a depression which lies just below the incisor teeth, gives origin to mentalis and mental slips of the orbicularis oris. (Fig.3)

Inner surface of mandible

Fig .4



Mylohyoid line - prominent ridge running obliquely downwards and forwards from below the third molar tooth to the median area below genial tubercles. It gives origin to the Mylohyoid muscle, Superior

constrictor muscle and Pterygomandibular raphe. (Fig.4)

Submandibular fossa - it lies just below the Mylohyoid line where the Submandibular gland lies.

Sublingual fossa - it lies above Mylohyoid line where sublingual gland lies.

Superior and inferior genial tubercles - four small elevations in posterior aspect of Symphysis menti. Superior genial tubercle gives origin to genioglossus and inferior genial tubercle gives origin to geniohyoid. (Fig.4)

Mylohyoid groove - it lies below the posterior end of Mylohyoid line extending to Ramus.

Upper border - it holds the sockets of teeth.

Lower border - near the midline an oval depression called digastric fossa, anterior belly of digastric muscle arises from the fossa. Platysma is inserted in this border.

Ramus of the mandible

Quadrilateral in shape and has upper, lower, anterior and posterior borders, lateral and medial surfaces.

Lateral surface

It is flat and having number of oblique ridges, Masseter inserted into it.

Medial surface

Mandibular foramen

It lies above the centre of Ramus leads to mandibular canal and descends into body of mandible and opens at mental foramen. Mandibular canal gives entry to Inferior alveolar nerve and vessels through mandibular foramen. (Fig.4)

Lingula - anterior margin of mandibular foramen. It gives attachment to Sphenomandibular ligament.

Mylohyoid groove - it lies below the mandibular foramen. Medial pterygoid muscle is inserted into the groove. In this groove, Mylohyoid nerve and vessels lie.

Upper border

Thin and curving downwards forming mandibular notch.

Lower border

Continuation of lower border of body. Posterior border is thicker than anterior border.

Coronoid process - flat triangular projection in the anterosuperior part of Ramus. Temporalis is inserted into it.

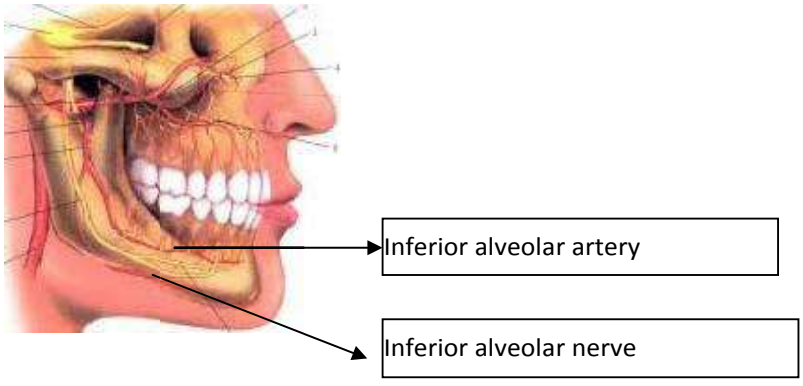
Condyle - an upward projection from poster superior part of Ramus. Fibro cartilage covers the head and articulates with temporal bone forming temporomandibular joint. Neck is the constriction below the head.

A depression in the anterior surface is called pterygoid fossa where lateral pterygoid muscle is inserted.

BLOOD SUPPLY

Inferior alveolar artery supplies the mandible. The artery arises from maxillary artery and descends between and Ramus and spheno mandibular ligament of the mandible. The inferior alveolar artery and nerve via mandibular foramen enters the body and exit via the mental foramen. The artery lies posterior to the nerve. Mandible also receives blood supply from its muscle attachments. (Fig.5)

Fig. 5



NERVE SUPPLY

Inferior alveolar nerve supplies the mandible.

Uniqueness of the mandible

Thick cortical bone with single vessel for endosteal blood supply. It varies with patient's age and amount of dentition. As the mandible atrophies, the endosteal blood supply is decreased and periosteal blood supply is the dominant.

Mandible elevators

1. Masseter
2. Temporalis
3. Medial pterygoid

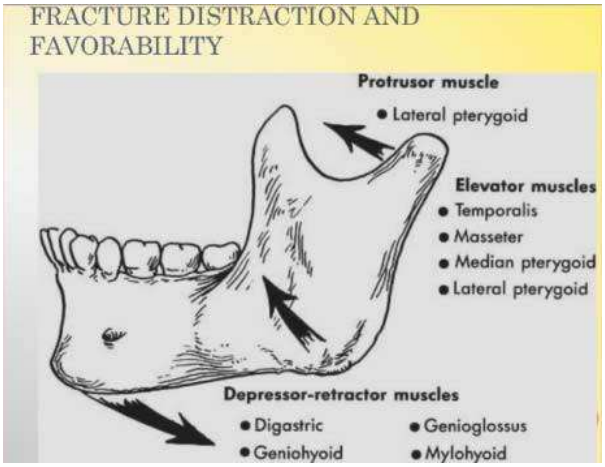
Mandible depressors

1. Lateral pterygoid
2. Mylohyoid
3. Digastric
4. Geniohyoid

All the muscles of mastication are supplied by mandibular branch (V3) of trigeminal nerve.

MUSCLE ATTACHMENTS AND DISPLACEMENT OF FRACTURES

Fig. 6



Masseter

It arises from the zygomatic arch and maxillary process of zygomatic bone. Inserted into the lateral surface of Ramus of mandible.

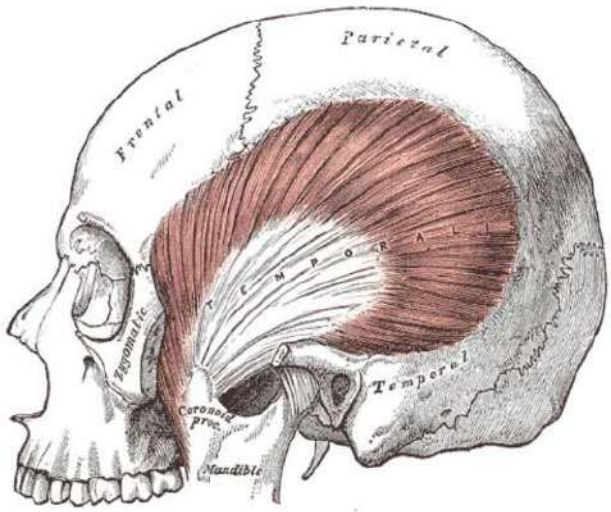
Action - Elevation of mandible.

Temporalis

It arises from the temporal fossa. It is inserted into the Coronoid process and anterior margin of Ramus of mandible. (Fig.7)

Action -Upper and anterior fibers elevate the mandible, posterior fibers retract the mandible.

Fig. 7



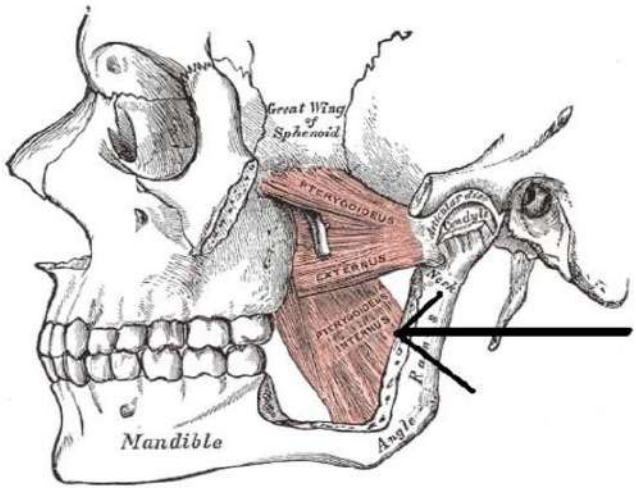
Medial Pterygoid

It has two heads superficial and deep. Deep head is larger and it arises from the medial surface of the lateral pterygoid plate the pyramidal process of the palatine bones. Superficial head arises from the tuberosity and pyramidal process of maxilla

It is inserted into the medial surface of mandible near angle.

Action - Elevation and side to side movements of mandible.

Fig. 8



Lateral pterygoid

It has two heads. Superior head arises from the infratemporal fossa. Inferior head arises from the lateral surface of the lateral pterygoid plate and both fuse into a short thick tendon that inserts into pterygoid fovea in the neck of mandible and to the capsule of temporomandibular joint. (Fig.8)

Action - Side to side movement and protrusion of mandible.

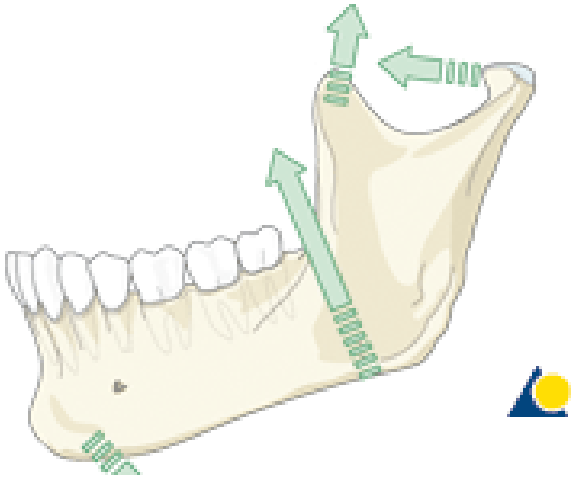
BIOMECHANICS OF MANDIBLE

Biomechanics of Mandible is a complex one. The forces applied to the mandible cause varying zones of tension and compression depending on where the bite force is located.

Muscle forces

Mandible is a hoop of bone that deforms with movement based on the origin and insertion of the muscles of mastication.

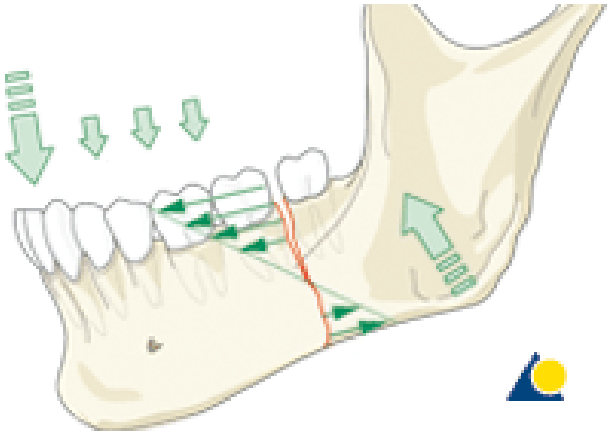
Fig. 9



Tensions and compression zones

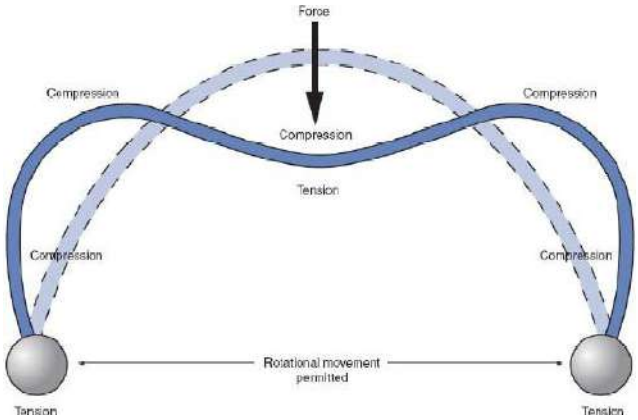
Superior border of the mandible is the tension zone and the inferior border is the compression zone.

Fig. 10



Hunting bow concept

Fig. 11



The mandible is similar to a hunting bow in shape, strongest in the midline (Symphysis) and weakest at both ends (condyles). The most common area of fracture in the mandible is therefore the condylar region. A blow to the anterior mandibular body is the most common reason for condylar fracture. The force is transmitted from the body of the mandible to the Condyle. The Condyle is trapped in the glenoid fossa. Commonly, a blow to the ipsilateral mandible causes a contra lateral fracture in the condylar region. (Fig.11)

If the impact is in the midline of the mandible, fractures of the bilateral condylar region are very common. With a condylar fracture, there is very often shortening of the Ramus on the affected side. This will result in an ipsilateral premature contact of the teeth. In case of bilateral fractures, the patient may present an anterior open bite. The condylar fragment may be displaced (most often laterally) based on the angulation of the fracture and predominant muscle pull.

AO Principles of fixation

Superior border plate should be positioned on the ideal line of osteosynthesis. Inferior border plate should be located at the base of the mandibular body below the course of the mandibular canal in a longitudinal field.[17]

Ideal line of osteosynthesis

In the body region, it runs at the vertical height of the tooth apices from the canine region to the oblique line. This carries into the oblique ridge which turns into the anterior outer rim of the Ramus. According to **Champy**[15] in the transition to the Symphysis (anterior mandibular body) the insertion of two plates along the upper and lower border is mandatory because there may be rotational forces that have to be neutralized. In the posterior transition to the angle and Ramus a second plate just below the oblique ridge may be advantageous in a reduced bone stock due to impacted wisdom tooth or in major dislocations.

Fig. 12

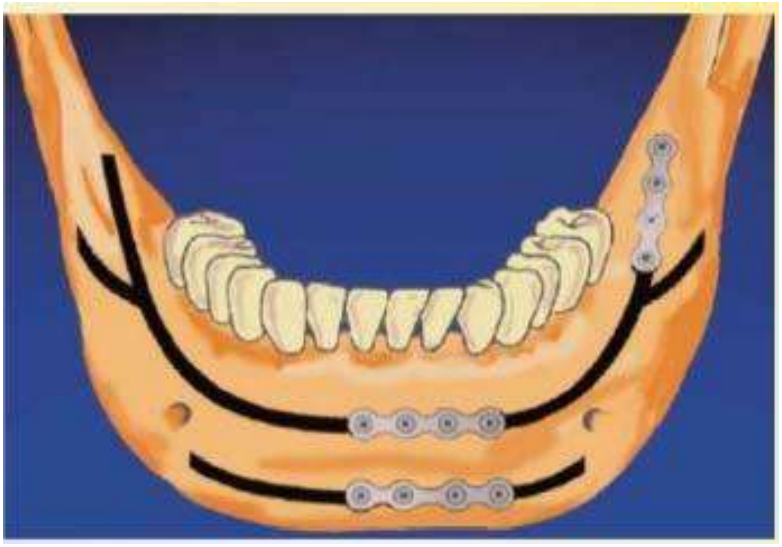
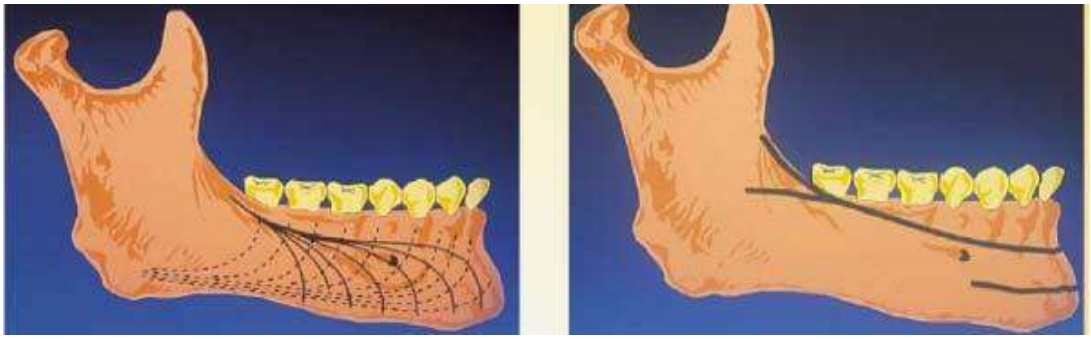


Fig. 13



Two point fixation (two plates) provide more stability than a single plate.

Addition of a second plate provides more rigidity.

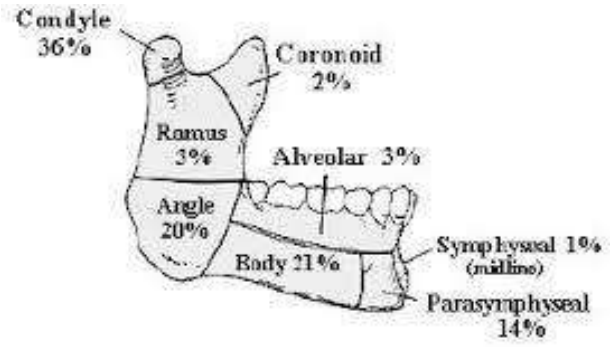
Sequence of plate insertion

Superior plate is inserted first in order to achieve preliminary fixation. This will prevent inadvertent displacement of the fragments during subsequent contouring and insertion of inferior border plate.

CLASSIFICATION

1. **Dingman and Natvig classification** according to the anatomical location site

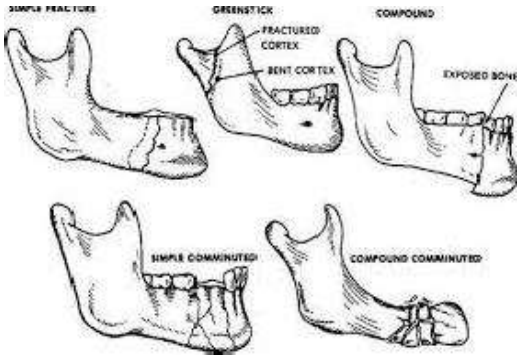
Fig. 14



2. KRUGER'S General classification

a. Simple fracture / closed
b. Compound fracture / open
c. Communited fracture
d. Complex or complicated fracture
e. Green stick fracture
f. Impacted fracture
g. Pathological fracture

Fig. 15



3. ROW AND KILLEY'S anatomical Classification

a. Fracture not involving basal bone (e.g) Dento alveolar fracture

b. Fracture involving basal bone

1. Single unilateral fracture
2. Double unilateral fracture
3. Bilateral fracture
4. Multiple

4. Completeness of fracture Complete fracture Incomplete fracture

5. According to the presence or absent of tooth in relation to fracture line Kazanjian and Converse

Class I - when the teeth are present on both sides of the fracture line

Class II - when the teeth are present on one side of the fracture line

Class III - when teeth are absent on both sides of the fracture line

6. Favorable and unfavorable fractures

Fig. 16

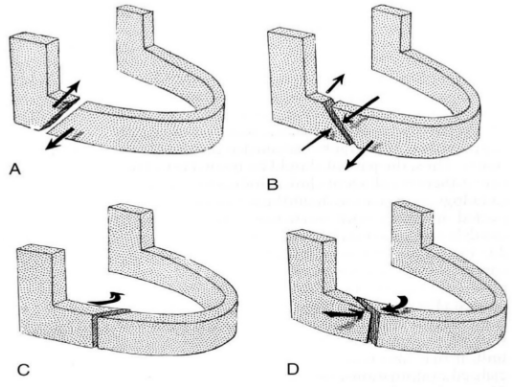
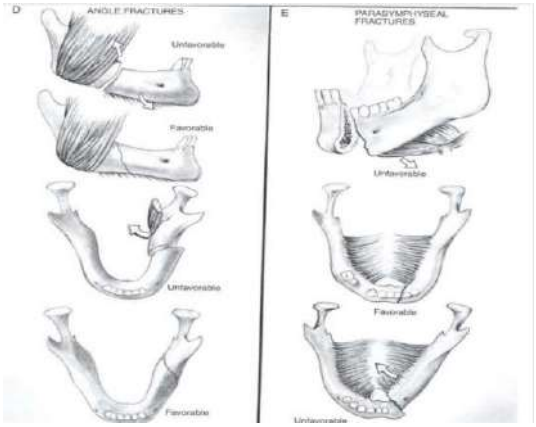


Fig. 17



a. Horizontally unfavorable, b. Horizontally favorable,

c. Vertically unfavorable, d. Vertically favorable

Mode of injury

1. RTA
2. Interpersonal violence
3. sports injury
4. Fall
5. Industrial trauma

Mechanism of injury

1. Direct violence
2. Indirect violence
3. Excessive muscular contracture - fracture of the Coronoid process because of sudden reflex contracture of the temporalis muscle.

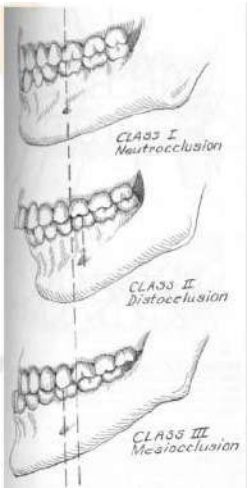
Angle classification of occlusion (1887)

Class I - Mesiobuccal cusp of the maxillary first molar occludes with the mesiobuccal groove of the mandibular first molar

Class II-Mesiobuccal groove of the mandibular first molar is distal to the mesiobuccal cusp of the maxillary first molar

Class III -Mesiobuccal groove of the mandibular first molar is mesial to mesiobuccal cusp of the maxillary first molar.

Fig. 18



METHOD OF FIXATION

Closed reduction

Indications

1. Non displaced favorable fractures
2. Fractures in children with developing dentition
3. Coronoid and high condylar fractures
4. Grossly comminuted fractures
5. Edentulous fractures with the use of prosthesis and circum mandibular wires

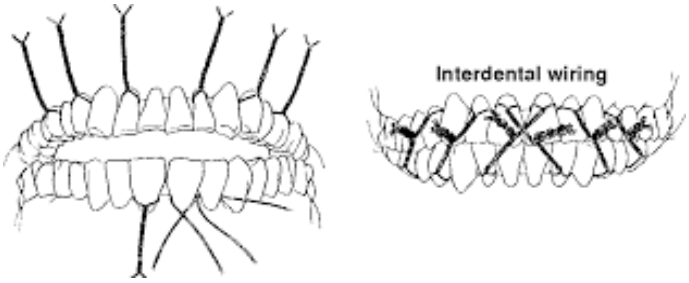
Splints

1. Gunning splints
2. Lingual splints

Wiring techniques

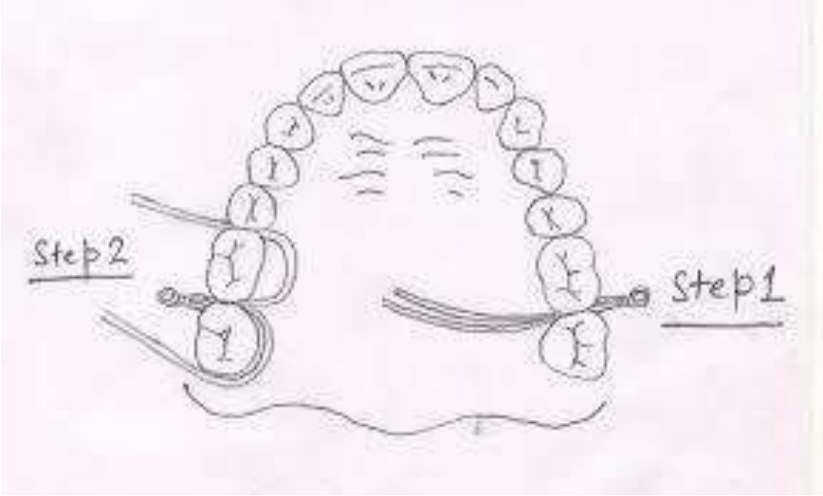
1. Glimer method

Fig. 19



2. Eyelet method

Fig.20



3. Erich arch bar method

Fig. 21

4. Orthodontic bands

5. Acrylic splints

Maxillomandibular fixation

Maxillomandibular fixation refers maxillary and to fixation of mandibular teeth together with wiring. Three to four weeks of is needed. Weight fixation loss has been reported due to MMF.

1. Eyelet method
2. Arch bar method
3. Intermaxillary fixation screws (Fig. 22)
4. Circumferential wiring
5. External pin fixation

Fig. 22

Open reduction

Indications

1. Displaced unfavorable angle , body and parasymphyseal fractures
2. Patients with multiple facial fractures that require a stable mandible for basing reconstruction.
3. Bilateral displaced condylar fractures
4. Fractures of an edentulous mandible with severe displacement
5. Medically compromised patients
6. Comminuted fractures

Contraindications

1. Severely comminuted fractures
2. Grossly infected fractures
3. Patients with healing problems (radiation ,chronic steroid use, transplant patients)

Methods of fixation

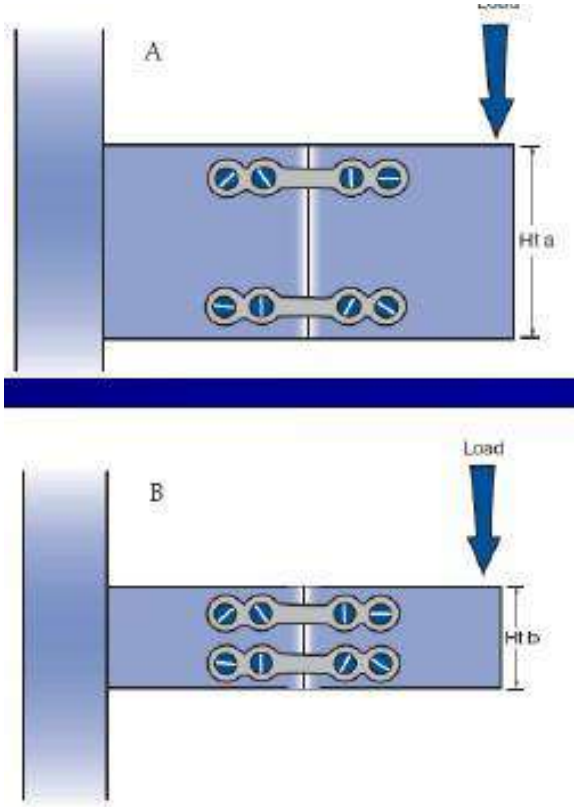
1. Dynamic compression plates

In plates with compression holes, as the screw is tightened the screw - bone unit is moved towards the fracture site impacting against the bone on the opposite side of the fracture. Screws inserted bicortically this promotes primary bone healing.

2. Miniplates

The term “miniplate” refers to a plate thickness of 1.3 mm or less. (Fig.23). Mandibular miniplates are designed to be used with monocortical screws. Bicortical screws may be used for additional stability in some cases (with plate thickness being the limiting factor)

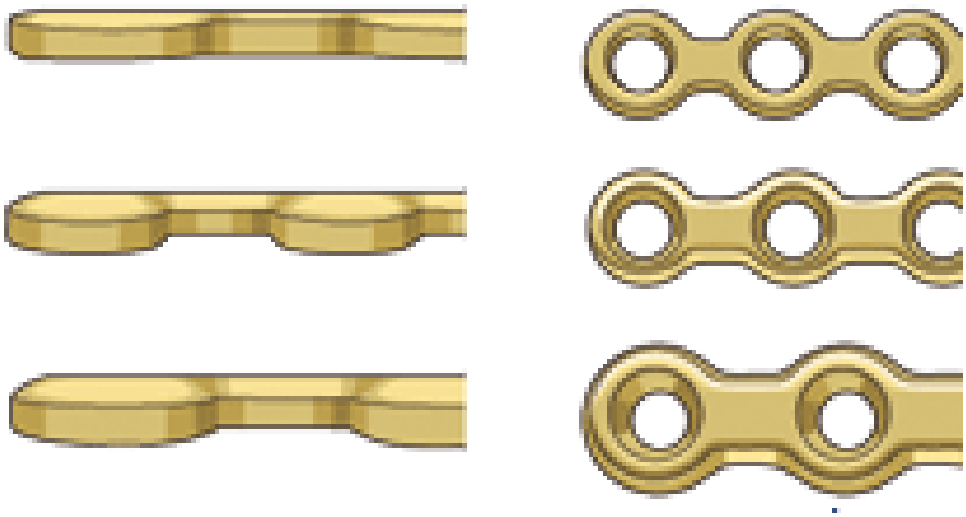
Fig. 23



3. Locking plates

In locking plate system the hole in the plate is engineered to accept screws that lock to it by a second thread under the head of the screw.(Fig.24) These plates function as internal fixators achieving stability by locking the screw to the plate. The advantage of this system is that it is unnecessary for the plate to have intimate contact with the underlying bone, making plate adaption easier leading to lesser alteration in the alignment of the segments and changes in the occlusal relationship upon screw tightening. It does not disrupt the underlying cortical bone blood supply. The screws are unlikely to loosen from the bone plate.

Fig. 24



4. Lag screws

The principle is to place one or more screws through fragments so that the threads of screws take hold only in the far or deep cortical bone. This is effective in oblique fractures. The screw has to be placed perpendicular to the fracture. Since a single lag screw cannot resist rotation, at least two lag screws are required to resist the rotation.

Fig. 25

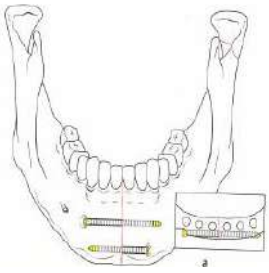
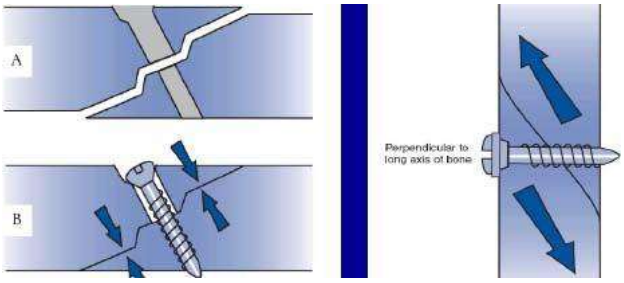


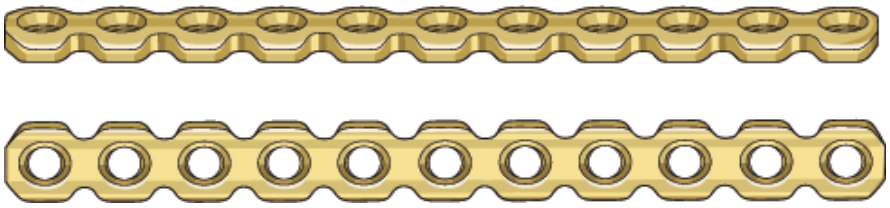
Fig. 26



5. Reconstruction plate

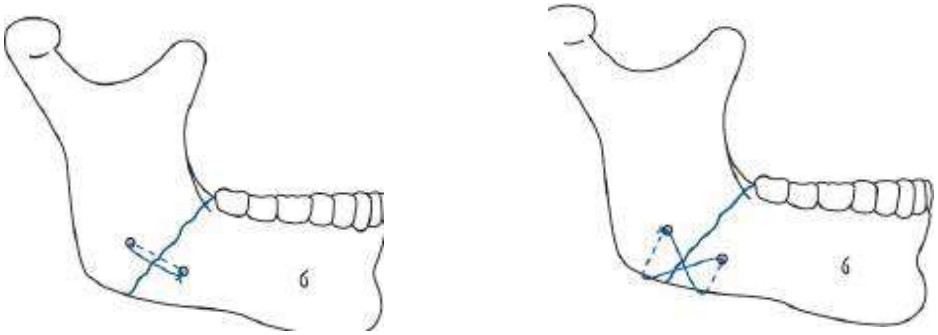
These plates are used for load bearing osteosynthesis of mandibular fractures.

Fig. 27



6. Intraosseous wire fixation

Fig. 28



ACCESS TO THE MANDIBLE

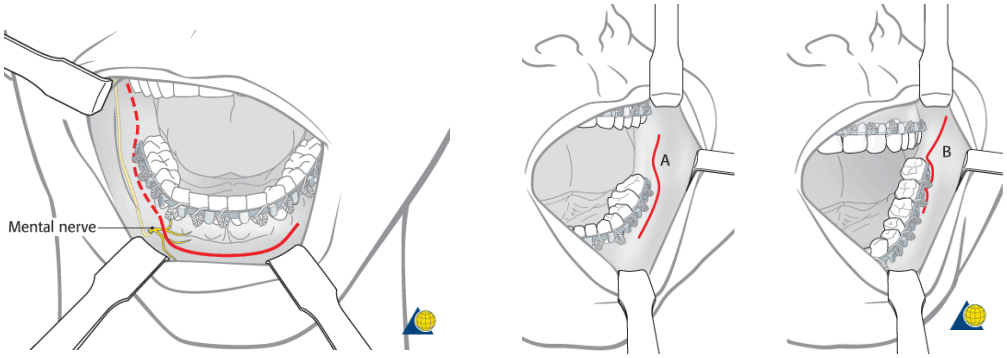
Good exposure of the fracture site is an absolute prerequisite for good surgical outcome. In face importance should be given for future scar and care should taken to avoid injury to nerves and muscles of facial expression.

INTRA ORAL ACCESS

1. TRANS ORAL LOWER BUCCAL SULCUS INCISION

Incision to be made in buccal mucosa in a U shaped manner (Fig.29) and not over gingiva. This incision gives a wide exposure of symphyseal, parasymphyseal and body fractures. Periosteal attachment should be retained whenever possible as the periosteal blood supply is the only remaining circulation. Hardware should be covered with well vascularized soft tissue two layers closure with muscle and mucosa is always effective. Mentalis should be repaired to avoid postoperative lip ptosis and lip ectropion.

Fig. 29 **Fig. 30**



Advantage

1. Occlusion status can be assessed continuously
2. Rapid approach
3. Avoids external scar

Disadvantage

1. Only labial cortex of the mandible is visualized. It is possible to have a significant gap in the lingual cortex.
2. Contracture of the vestibule

Complications

1. Mental nerve damage.
2. Lip ptosis and lip ectropion

2. TRANSBUCCAL ACCESS (TROCAR TECHNIQUE)

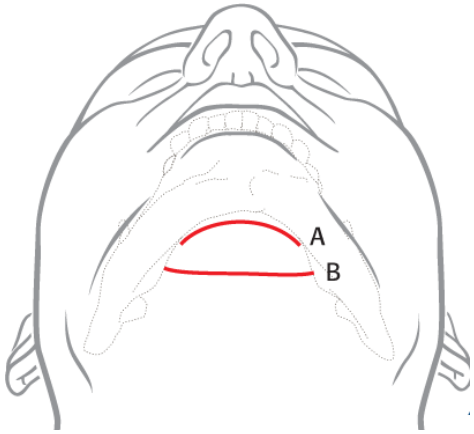
It is a combination of both intraoral and extra oral access. Trocar and specific instruments are used to place the screw. This access is used for body and angle fractures.

EXTRA ORAL ACCESS

A. SUB MENTAL APPROACH

This approach gives good exposure of symphyseal, parasymphyseal and anterior body regions.

Fig. 31



Advantage

1. Mentalis muscle is not divided.
2. Mental nerve is well protected.

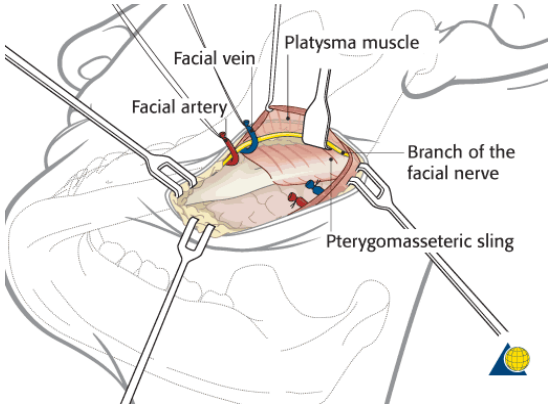
Disadvantage

External scar is present

B. SUB MANDIBULAR APPROACH (RISDON)

It is a 2 to 4 cm curved incision placed 2 cm below the inferior border of the mandible. Marginal mandibular nerve should be identified and protected. Attachment of the masseter muscle at the inferior border is divided and elevated. It gives good exposure to angle, ramus, mid body and particularly in comminuted fractures. This approach is also used in subcondylar fractures.

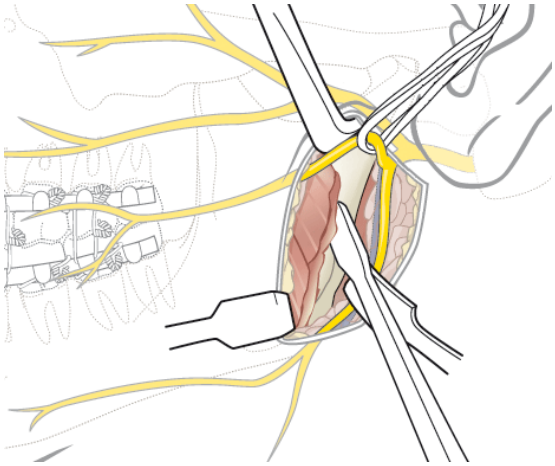
Fig. 32



C. RETRO MANDIBULAR APPROACH

An incision is made 1-2 cm posterior to the border of mandible. It gives exposure to angle, ramus and posterior body regions. Injury to Greater auricular nerve should be avoided.

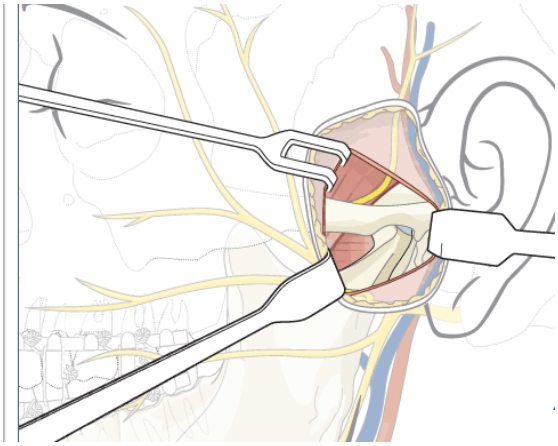
Fig. 33



D. PRE AURICULAR APPROACH

Used to expose condylar head and tempero mandibular joint .Facial nerve should be protected.

Fig. 34



E. POST AURICULAR APPROACH

Used for high condylar fractures

F. TRANS PAROTID APPROACH

This has been described for subcondylar exposure with dissection in the direction of facial nerve fibers to expose the bone through the parotid gland.

Advantage - It is directly over the fracture site.

Complications

1. Parotid fistula
2. Facial nerve injury

MANAGEMENT OF TEETH IN THE FRACTURE LINE

The problem in mandibular fracture management is dealing with teeth in the line of fracture. Commonly, there are impacted third molar associated with mandibular angle fractures. However, any fracture involving the dentate areas of the mandible has the chance to involve erupted teeth in the fracture line.

The surgeon can either remove the involved tooth or leave it in place if it is thought not to compromise the result of fracture management.

Indications for removing the teeth in the line of fracture

1. Tooth subluxated from its socket and interfering with reduction of the fracture.
2. Fractured tooth.
3. Tooth with advanced dental caries carrying a significant risk of abscess during treatment.
4. Tooth with advanced periodontal disease with mobility which could not contribute to the establishment of stable occlusion.
5. Tooth with existing pathology such as cyst or pericoronitis.

Indications for leaving the teeth in the line of fracture

1. Tooth not interfering with the reduction and fixation of fracture.
2. If tooth removal requiring removal of excessive amount of bone, it will lead to compromise in the fracture fixation.

3. Tooth that is in good condition and assists in establishing occlusion and reducing the fracture.

COMPLICATIONS

1. MALOCCLUSION

Malocclusion is the most common complication and functional problem.

Causes of malocclusion are

1. Inaccurate alignment in initial reduction (poorly applied MMF)
2. Severe comminution
3. Patient's non compliance.

Minor malocclusion can be corrected with occlusal splints. Severe malocclusion has to be corrected by refracturing or osteotomy and plates osteosynthesis with MMF.

2. DELAYED OR NON UNION

Delayed union is more commonly due to inadequate reduction and fixation. If a fibrous union is present , the fracture will heal with bony consolidation over a period of time .

Non union occurs due to

1. Infection
2. Inadequate opposition of bone.
3. Severe comminution with gap
4. Teeth in the fracture line

It has to be treated by re exploration and fixation with bone grafts.

3. MALUNION

Bone heals in abnormal position due to inadequate reduction and fixation.

Malunion has to be treated with osteotomy and re fixation with bone graft.

4. INFECTION

Infection is seen in compound fractures, excessive periosteal stripping, unstable fracture union.

5. EXPOSED OR LOOSE HARDWARE

Hardware get exposed when there is infection, wound contracture and when a dental prosthesis is worn over hardware. Minor exposure is managed conservatively till fracture union whereas major exposure requires hardware removal and more stable fixation.

6. SENSORIMOTOR DISTURBANCES

Sensory disturbances of inferior alveolar nerve and mental nerve can occur. Motor disturbances due to injury to marginal mandibular nerve and facial nerve have been reported.

7.EXACERBATION OF DENTAL DISEASE

If oral hygiene is not maintained there can be exacerbation of existing dental disease like caries.

8. TEMPOROMANDIBULAR JOINT DYSFUNCTION

Prolonged immobilization with MMF can lead to TMJ dysfunction. Simple jaw exercises and mechanical exercises can improve the condition. Myositis ossificans can occur when hematoma in the muscle organises and ossifies. The myositis has to be excised, but there is a chance of recurrence.

9. SCARS

Unsightly scar can occur in compound fractures. It can be managed initially with scar massaging followed by scar revision.

The first description of mandibular fracture was as early as 1650 BC, when an Egyptian papyrus described the examination, diagnosis, and treatment of mandible fractures. Hippocrates describe circumdental wires and external bandaging for reapproximation and immobilization. Surgeons such as Ceisus (Rome), Avicenna (Islam) and Sushruta (India), described treating the jaw fractures conservatively between 25 B.C. and 11 century AD.

Sushruta recommended complicated bandaging, manual manipulation and heat to treat fractures of mandible. The importance of occlusion during the treatment of fractures was studied by Avicenna (980 to 1037A.D). This concept is followed still today nearly 1000 years after his description. Salerno of Italy, in 1180 wrote in a textbook the importance of establishing proper occlusion. Maxillomandibular fixation was first described in 1492, in an edition of the book Cirugia printed in Lyons.

Dental prosthetic devices were used to immobilize fracture fragments by Chopart and Desault. Until 19th century fracture mandible was treated with wrap, external bandages and sometimes with bridle wire Hausmann (1886) was probably the first to describe a method of mandibular fracture stabilization by means of a screw plate system.

Schede (1888) used a true bone plate made of steel and secured with four screws. During the period between World War I & II skeletal fixation became popular. Roger Anderson (1936) modernized the method and produced an appliance by which the fracture fragments could be controlled by means of pins or screws inserted through the skin.[18]

In late 19th century, open reduction and internal fixation were used in treatment of jaw fractures. These methods came into dispute because of high rate of postoperative infection. Circumferential wiring was advocated by G.V. Black and Ivy (1921). During World War I Kazanjian used transosseous wiring placed through an intraoral approach into the alveolar part of the bone.

In 1913 Lambotte recommended aluminium, geometrically closed quadrangular plate secured with bone screws at the lower border of mandible for the treatment of fracture of the mandible body via an extra oral approach. This plate osteosynthesis offered sufficient stability without immobilization. However this method did not gain popularity may be due to the lower biocompatibility of the material.

In 1917 Cole used silver plates and screws on each side of the fracture and then silver wires attached to the plates, to immobilize the fracture. In 1934 Vorschutz introduced two large screws through the skin into the bone, reduced the fracture and held the screw in the position with the use of plaster of paris bandage.

Danis was the first to design a rigid longitudinal compression system using a plate screwed to the bone cortex and compressed by a device incorporated in the plate. Using this technique, Danis was successful in securing radiological “Primary bone healing” in fracture of forearm bone and of the tibia. He called such a healing as “Sonder Autogene”.[19]

In 1958, a group of Swiss general and orthopaedic surgeons founded an association for the study of osteosynthesis, with their development of new instrumentation and methods, which allowed absolute immobilization of bone fragments by means of compression osteosynthesis. The problem of stable internal fixation appeared to be almost solved from the technical stand point.

In 1960, Luhr developed the vitallium mandibular compression plate through his research on rigid fixation of facial skeleton. In early 1970’s modification of orthopaedic principles and armamentarium were introduced to the maxillofacial trauma surgery by Spiessl through the Arbetsgemeeinschaft fur Osteosynthesefragen/ Association for the study of internal fixation (AO/ASIF). They found that adaptation of a compression plate on lateral cortex at the inferior border of mandible gave

excellent compression and adaptation at the inferior border. But the superior border splayed.[19,20]

Kruger (1964) felt that opening reduction with internal fixation was a definite method of anchoring bone segment at the fracture site. He stressed the need for additional maxillomandibular fixation, as direct interosseous wiring cannot be relied upon for complete immobilization of the fragments.[19]

Rijnko Brons (1970) achieved a stable osteosynthesis of fracture of mandibular body in 40 cases by means of plate fixation, functional screw fixation and by wire connection, which showed fast healing and intermaxillary fixation was omitted. They found no complications. Radiologically, fracture line disappeared within 6 to 10 weeks in 26 fractures and in 13 fractures after 10 weeks.

In 1973 Spiessl and Schmocker developed the eccentric dynamic compression plate (EDCP) which provided compression at the tension and compression zones of mandible. When the screws closest to the fracture were tightened, the fracture line could be placed under compression, when eccentric terminals were tightened, the alveolar segment would be reduced.[19]

Michelet et al (1973) first published the analysis of 300 cases treated with miniaturized screwed plates in maxillofacial region in which he obtained excellent results. This method allowed monocortical, sub apical and juxtaalveolar fixation without compression and intermaxillary fixation.[21]

Champy et al (1978) described the technique which consists of monocortical, juxtaalveolar and sub apical osteosynthesis compression without maxillomandibular fixation using malleable plates and screws through buccal approach. It was similar to that described by Michelet (1973). Also they described the ideal line of osteosynthesis. They applied this technique in 183 cases of mandibular fractures and concluded that it

was the most successful and simplest method of mandibular osteosynthesis without maxillomandibular fixation and compression.[22]

Raveh J et al developed further on the reconstruction system, by incorporating the principle of an external device into a bone plate. These plates achieve stability by locking the screws to the plate and have been shown to enhance fixation stability. Other reported advantage of this design includes fewer fixation screws per osseous segment and allowance for a less adaptation of plate to the underlying bone. Raveh and co-workers showed the effective use of these devices for mandibular reconstruction in 1987.[23,24]

Oikarinen K et al retrospectively reviewed 200 treated mandibular fractures and reported that only 6% of the fractures were treated by plate osteosynthesis and 50% by inter maxillary fixation.[25]

Frank Dal Santo et al in 1992 studied the effect of zygomatic complex fracture on masseter muscle force. Amount of force generated in masseter, post zygomatic fracture was determined using EMG studies and recording bite force using custom bite force transducers in 10 patients. Controls showed 49.5Kp on right side and 48.9Kp on left side on an average. Bite forces of patients with zygomatic fracture was 1.6Kp preoperatively. The study showed significant reduction in masseter force following fracture of the zygomatic complex.[26]

Gaylord S. Thockmorton et al in 1992 studied the bone strain following the application of rigid fixation on human cadaver mandibles. Static load of 60 kilo pounds were applied and the strains were recorded using 4 strain gauges. The result showed significant changes in the bone strain following application of rigid fixation to the mandible because of the difference in the modulus of elasticity of the bone and the metal.[27]

Vivek Shetty et al in 1992 did a study to evaluate the biomechanical validation of the lag screw technique for treating simulated angle fracture in 4 cadaver mandibles. Load displacement relation under functional loading was determined using transducers. Functional loading at the lag

screw, bone interface was recorded in photo elastic model and distraction tendency at the fracture site was monitored. It concluded saying the lag screw provided sufficient degree of inter fragment compression to resist functional forces.[28]

Arden K. Hegtevedt (1994) compared the resistance of miniplate and micro plate system to various forces, using a biomechanical model. He found that Luhr's mini system provided a significant amount of resistance to tensile and compression forces but is weakest when large forces are applied at 90º to the flat portion of the plate. They concluded that both systems may have enough strength to withstand the decreased masticatory forces generated immediately after osteotomy and maxillofacial bone fracture.[29]

Tuovinen V et al (1994) retrospectively analysed 279 patients with isolated mandible fracture treated with titanium miniplates using Champy's principles and concluded that semi rigid fixation of mandible fracture with miniplate is a viable treatment option for management of injuries.[30]

Gregory S. Tate et al (1994) recorded the voluntary bite forces in patients treated with rigid internal fixation for mandibular fracture angle and controls. Bite force was measured using custom bite force gauges. He found molar bite forces on the side of fracture in patients were less compared to controls. So he indicated that recommendations for the amount of fixation required for a given fracture may be reduced.[31]

Choi –BH et al (1995) in his invitro evaluation of mandibular angle fractures treated using two miniplate system – one plate along the superior border and a second plate applied at the inferior border of the buccal cortex noted more stable fixation and greater resistance against displacing forces are achieved with two plates and concluded that the two miniplate fixation technique is indicated in cases of mandibular angle fracture to achieve stability fracture site and early mobility of the jaw.[32]

Lawrence Marentette et al in 1995 studied the use and advantages of miniplate osteosynthesis of mandible fracture and concluded that the

advantages were intraoral placement, no injury to nerve or adjacent vital structures, no scarring, simultaneous reduction and fixation and occlusal adjustments were possible.[33]

Vivek Shetty et al (1995) did a study on 6 sets of mandible analogue, each set consisting of 3 mandibles. Fracture was simulated in the study models and EDCP, Wurzburg, Luhr plate, Lag screw, Champy miniplate, Mennen clamp plate were used for fixation. 22 DaN was applied on all mandibles and the displacement along the fracture line to occlusal forces, was measured. It was found that compression fixation system (EDCP, Wurzburg, Luhr plate, Lag screw) are biomechanically superior to adaptive system (Champy miniplate, Mennen clamp plate) and provided good immediate functional stability.[34]

Renton TF et al in 1996 did a study on 205 cases of mandible fractures. 83 cases were treated with mini plates following Champy's principles, 40 cases ignoring Champy's principles and 82 cases by transosseous wiring. Patients treated with mini plate osteosynthesis adhering to Champy's principles were most successful with minimal complication rates.[35]

Kuriakose et al (1996) studied 266 cases of mandibular fractures treated by compression plating and mini plate osteosynthesis and found that the complications of mini plate osteosynthesis was greater than that of the compression osteosynthesis group.[36]

Robert A. Rudman et al (1997) conducted a study to reassess Champy's finding which were instrumental in justifying the theory of tension band plating for mandibular angle fracture. They used mandibles which were fabricated with photo elastic resin for their study. They found that stress fringes were present surrounding the outer screws, indicating that these screws were subjected to pull out forces. They concluded that there is greater force on the outer screw that may contribute to fixation failure, and that the theory of tension band plating for mandibular angle fracture is accurate but Champy's model is over simplified.[37]

Alan S. Herford et al (1998) analysed the use of a locking reconstruction bone plate / screw system for fractures of mandible and continuity defects in 84 patients and found them to be simple and advantageous over conventional bone plates by not requiring the plate to be compressed to the bone to provide stability.[38]

F.A. Fontijn – Tekamp et al in 1998 studied the bite force with mandible implant retained overdenture. Transducers were used for the study and it showed the implant retained overdenture wearers had significantly higher bite force than that of complete denture wearers.[39]

James W. Sikes et al (1998) compared the fixation strengths of locking head and conventional screws in fracture and reconstruction model. They concluded that locking head screws provided significantly increased resistance to displacement when only two screws per segment were used in the reconstruction model. When four screws were used there was no significant difference between locking head and conventional screw types. The effect of bony buttressing is significant and may explain why miniplates often fail in the atrophic mandible but are successful in fully dentate patients.[40]

Sodeyama A et al in 1998 studied the reproducibility of maximal clenching force in 10 individuals with normal dentition. Prescale film was used for the study and the maximal bite force was recorded twice at a span of 3 years. The use of the prescale film was found to be useful for longitudinal evaluation of the masticatory system.[41]

Reena M. Talwar et al in 1998 studied the adaptation of the masticatory system after bilateral mandibular condylar process fractures in 22 patients treated by open reduction and internal fixation. Mandibular range of movements, bite force, muscle activity, estimated joint force was determined at the end of 6 weeks, 6 months, 1 year, 2 years and 3 years. It was concluded that there is early reduction in Mandible range of movements, bite force, muscle activity and joint force thus preventing the overloading of the fractured condylar process.[42]

Hidaka et al in 1999 studied the influence of clenching intensity on bite force balance and average bite pressure. Dental prescale film was used for the study and was concluded that the bite force and contact area increased with an increase in clenching force.[43]

Shinogaya T et al in 1999 evaluated the bite force and occlusal load distribution in normal complete dentition of 23 dental students. Prescale film was used for the study and the results were found to be useful as a basic model for evaluating occlusion.[44]

Gaylord S. Throckmorton et al in 2000 studied the morphologic and biomechanical correlates with maximum bite force in orthognathic surgery patients. 121 orthognathic surgery patients and 80 control's lateral cephalograms were traced. The bite was measured using transducers and EMG activity of masseter, anterior and posterior temporalis were recorded. Correlation was found between the difference of anterior and posterior facial height to the maximal bite force.[45]

Kisoshi Haroda et al in 2000 used a pressure sensitive device to measure the changes in bite force and occlusal contact area before and after bilateral sagittal split ramus osteotomy. Post op measurements were done at 2 weeks, 4 weeks, 8 weeks, 3 months and 6 months. The new pressure sensitive device was found to be simple and reliable in measurement of bite force and contact areas.[46]

B. Saka et al in 2000 studied the mechanical and biomechanical measurement of 5 osteosynthesis system of self tapping screws. The study was done on cadaver skulls and mandible. The pullout strength was measured using electronic transducers and the result showed champy's 2mm screws to have the maximum pressure force (153.4N). Minimum was Wuerzburger 2x5mm screws which was 92.9N. Skull was found to have more retentive forces than mandible and 2x7mm screws had 23-34% more pressure force than 2x5mm screws.[47]

Jose C. Moreno et al studied the complication rates associated with different treatments for mandibular fractures and concluded that the complication rates were based on severity of fractures rather than type of treatment modality used.[48]

Edward Ellis III et al in 2001 published an article titled “Bite forces after open or closed treatment of mandibular condylar process fractures.” The authors did the study on One hundred and fifty-five patients (127 male, 28 female) with unilateral fractures of the mandibular condylar process (91 treated closed and 64 treated open). Maximum voluntary bite forces were measured at 6 weeks, 6 months, and 1, 2, and 3 years after fracture treatment using transducers. They concluded saying that the maximum voluntary bite forces in patients treated for mandibular condylar process fractures do not differ significantly when treatment is open or closed. Neuromuscular adaptations to the fractured mandibular condylar process occur in both groups.[49]

Lindqvist et al in 2001 compared four screw-plate locking systems in 16 adult Finnish sheep both clinically and radiologically, 1 and 2 months post- operatively and concluded that the plates in this study fractured too easily and did not seem to have the qualities required to withstand the multidimensional functional loadings encountered in Mandibular defect reconstruction.[50]

H. Miura et al in 2001 did a study to compare the maximum bite force and dentate status between healthy and frail elderly persons. He used dental prescale film for the study and says this system is highly advantageous for assessing bite force in an epidemiological survey.[51]

Richard H. Haug et al (2001) evaluated the biomechanical behaviour of a vast array of fixation philosophies and techniques that address mandible angle fracture. They used 150 polyurethane synthesis mandible replicas. Fourteen different philosophies and techniques were subjected to vertical loading at the incisal edge and then repeated for contra lateral loading at molar region by Instron 1331 servo hydraulic

mechanical testing unit. Under these conditions all systems met or exceeded currently identified postoperative functional requirements for incisal edge loading but failed to meet them for contralateral molar loading.[52]

Ellis III et al (2002) conducted a study to evaluate the use of a 2 mm locking plate / screw system of mandibular fracture surgery in 59 patients. 2 mm locking plate / screw system was found to be simple and to provide sound fixation in all cases.[53]

K. L. Gerlach et al in 2002 published an article titled “Bite forces in patients after treatment of Mandibular angle fractures with miniplate osteosynthesis according to Champy”. In the study he had treated 22 patients for angle fracture of the mandible according to Champy’s principles and recorded the bite force of the patients 1st to 6th week post-operatively, using transducers. He concluded saying that after surgical fracture treatment 1 week postoperatively only 31% of the maximal vertical loading found in controls was registered. These values increased to 58% at the 6th week postoperatively.[54]

Ralf Gutwald et al in 2002 described in detail about the principles and stability of locking plates and showed that the locking principle prevents stripping as well as movement and loosening of screws. He also proved that the fixation technique imitates the principles of a fixateur and simplifies plate bending and decreases torsion or opening at the fracture site. He proposed that the increased stability is a result of the frame construct and load transmission. The absence of pressure underneath the plate prevents interference with the vascular supply of the bone and allows periosteal growth under the plates supporting fracture healing.[55]

Richard H. Haug et al (2002), in their invitro study using 130 polyurethane synthetic mandible replicas investigated in locking and non locking plates, whether plate adaptation affect the stability. They studied with samples in which plates were intimately adapted, 1mm offset and 2mm offset and were subjected to loading at the mechanical behaviour of

the non-locking system evaluated. It did not affect the locking systems. Failure occurred as an “all or nothing pattern”.[56]

Richard H. Haug et al in 2002 evaluated the biomechanical behaviour of various rigid internal fixation techniques for mandibular condylar process fractures. Study was done on 100 synthetic mandible replicas which was divided into 5 groups and was fixed with A- No fixation, B Six-hole 2.0-mm zygomatic dynamic compression plate, C Six-hole 2.0-mm locking adaptation plate, D Six- hole 2.0-mm adaptation plate and E Six-hole 2.0-mm mini dynamic compression plate. Results suggested that none of the systems evaluated were ideal for the treatment of mandibular condyle fractures, but that the mini dynamic compression plate is the closest to an effective means for reconstruction.[57]

Richard H. Haug et al in 2002 did a study to compare the effects of plate adaptation of conventional and locking plates on outcomes of mandible fracture reduction. He concluded that the plate adaptation was not that crucial to fracture reduction in locking plates than that compared to conventional plates.[58]

Brian Alpert et al in 2003 published an article titled “New innovations in craniomaxillofacial fixation” where he described in detail the 2.0mm lock system.[59]

David Kirkpatrick et al in 2003 did a retrospective review to determine the rate of infections associated with locking reconstruction plates. Of 56 locking reconstruction plates used in 42 patients, 3 fracture sites developed infection and in 3 patients, the preoperative infection persisted. So it was concluded that locking plates are useful in managing complicated fractures but it does not eliminate the complications.[60]

Ellis III et al (2003) assessed the methods of treatment used and outcomes for 196 patients with comminuted mandibular fracture. They showed that when possible the use of open reduction and internal fixation is associated with a low complication rate. However not all comminuted fractures are amenable to this treatment and in those alternatives such as

closed reduction with maxillomandibular fixation or the application of external pin fixation may be necessary.[61]

Ralf Guldwald et al (2003) compared a new internal mini locking system with conventional 2mm miniplates in 16 human cadaver mandibles. They showed that in case of miniplate fixation gapping of the bone fragments occurred following miniplate application and screw tightening when the plates were pressed onto the bone. So, incongruousness between bone surface and plate are transferred to the mobile bone fragments resulting in more extended gaps and torsion. This was observed to a much lesser extent with the mini locking system due to the fixation principle avoiding pressure to the bone. During functional loading mini-locking system also showed a significant higher stability in comparison to conventional miniplates.[62]

Marisa Aparecida Cabrini Gabrielli et al reviewed 191 cases of mandibular fractures fixed with 2.0-mm miniplates and concluded that it was a reliable treatment modality for managing all types of mandibular fractures.[63]

Chad P. Collins et al in 2004 conducted a prospective randomized clinical trial comparing 2.0-mm locking plates to 2.0-mm standard plates in treatment of mandible fractures in 90 patients with 122 fractures and concluded that mandible fractures treated with 2.0-mm locking plates and standard 2.0-mm plates present similar short-term complication rates.[64]

Kenneth A. Egol et al in 2004 described the biomechanics of locked plates and screws in details. A complete orthopaedic literature search was made and concluded that the locking and conventional fixation techniques rely on completely different mechanical principles and thus both provide different environment for fracture reduction and healing.[65]

Kaoru Kohyama et al in 2004 studied the effect of cross sectional area of raw carrot and surimi gel on human bite force. The bite force was recorded using multiple point sheet sensors and EMG of the muscles. It

was found that, the bite force, contact area, stress between the teeth increased with increase in cross section of the food chewed.[66]

Nils Claudius Gellrich et al in 2004 compared THORP and UNILOCK system in reconstruction of mandibular defects. Retrospective study was done on 107 patients and was concluded that there was no statistically significant difference between the two systems of locking reconstruction plates.[67]

Olegn Militsakh et al in 2004 did a retrospective study in 43 patients who underwent composite resection of the mandible and reconstruction with osteocutaneous flap, which was fixed using 2.0mm locking reconstruction plate. There has been no earlier study of this kind and the study concluded that the use of locking reconstruction plate is reliable in settings of previously irradiated mandible or in mandible where post op radiotherapy has been planned.[68]

Yukio Kitafusa in 2004 used prescale film to aid in diagnosis for orthodontic treatment. It was used for determining the occlusal contact area and occlusal force. He concluded that the dental prescale occluzer system has an advantage of being able to evaluate occlusion at nearly physiologic conditions because the film thickness is very thin and will not interfere in the ordinary occlusion at centric position.[69]

Ayman Chritah et al in 2005 did a prospective study of 50 mandible fractures in 34 patients, who were treated with 2mm locking plates followed with 1 week maxillomandibular fixation. Primary bone healing occurred in 98% and in 3 patients, complications occurred. The high success rate made the author conclude that this modality of treatment of mandible fracture is reliable.[70]

Alper Alkan et al in 2006 used the dental prescale film to determine the bite force and occlusal contact area changes following distraction osteogenesis and mandibular widening. 15 patients were chosen for the study and the bite force was recorded preoperatively, 1 week, 1 month,3 months, 6 months and 1 year post operatively. It was found that the

preoperative force was regained at the end of 6 months and bettered the preoperative values at the end of 1 year.[71]

Arzu Alkan et al in 2006 used the dental prescale film to determine the effect of periodontal surgery on bite force, occlusal contact area changes and bite pressure determination. 10 patients underwent the periodontal surgery and the values recorded were compared with that of 10 controls. Results showed no significant changes in bite force following periodontal surgery.[72]

Buecker et al in 2006 undertook a study to assess the performance of locking plates against conventional plates for fixation of allograft after resection of tumours of the mandible. Results showed that the locking plates used for allograft fixation showed better union rates and less need for additional operations when compared to conventional plates.[73]

Bousdran V.A et al in 2006 fabricated a polyurethane splint with force sensors fitted onto the occlusal surface. The bite force with this custom made splint was measured in porcine models. The regular mastication force was found to be between 200 and 560N.[74]

B. Frerich et al in 2006 did a study comparing locking and non-locking miniplate osteosynthesis in mandible fracture. This was the first prospective study comparing the two types of miniplate osteosynthesis in 65 patients (27 angle, 18 subcondylar and 20 combined fractures). Radiographic and clinical assessments were made pre-operatively, 2 months postoperatively and 6 months postoperatively. Complication occurred in only 1 patient and hence it was concluded saying the miniplate locking screw is safe and easy to use intra operatively and has got better handling properties than the non-locking plates.[75]

Luciana Asprino et al in 2006 did biomechanical evaluation of condylar fracture plating technique, in synthetic hemi mandible replicas, using single 4 holed plate with 6mm screws, single 4 holed plate with 8mm screws and two 4 holed plates with 6mm screws. Loading was done using

Instron 4411 servo hydraulic testing unit. Two 4 holed plates with 6mm screws was found to have better biomechanical stability.[76]

Thomas A. Chiodo et al in 2006 studied the failure strength of 2.0 locking and 2.0 conventional synthes mandibular plates. 10 locking and 10 non locking were used in randomly selected osteotomized bovine ribs. Force was applied in four point bending system to the point of failure. Non locking failed at 559.9N and locking failed at 637.8N. The type and degree of failure was related to bone quality and surgical technique and there was no significant difference observed between the two systems.[77]

Sebastian Sauerbier et al in 2008 reviewed the development of plate osteosynthesis for the treatment of fractures of the mandibular body and concluded that modern miniplates have great advantages, like the intra-oral approach and the easy adaptability, and it is no longer necessary to expose bone as extensively.[78]

Martyn Snow et al in 2008 did a study in 5 synthetic mandible comparable to mandible of 80 year old female, to determine if locking compression plates (LCP) are mechanically advantageous compared to low-contact dynamic compression plates (DCP) when used as a bridging plate in the synthetic model of osteoporotic bone. The results showed that the LCP was mechanically superior to the DCP when used as a bridging plate and tested in axial compression.[79]

MATERIALS AND METHOD

The present study was carried out in Department of Plastic Surgery at Dayanand Medical College and Hospital, Ludhiana. All patients who attended the Emergency or OPD at Dayanand Medical College and Hospital Ludhiana, willing to be a part of the study were included in the study.

INCLUSION CRITERIA

All patients who underwent open reduction and internal fixation for isolated mandibular fractures in the Department of Plastic Surgery from January 2018 to June 2019 were included in the study.

EXCLUSION CRITERIA

(1) Patients with associated mid-face fractures,

(2) Edentulous patients,

(3) Patients below 14 and above 45 years of age,

(4) Neurosurgically compromised patients.

(5)Patients with history of mental disorders, those who received tranquilizers, opioids > 1 week prior to surgery.

The study design includes a thorough case history taking in a case sheet which was custom made for the study as shown in the annexure. Preoperative investigations included

- Haemoglobin percentage
- Complete blood count
- Bleeding and clotting time
- Blood grouping
- Random blood sugar
- HIV and HbsAg HCV screening
- PA view chest and ECG as requested by physician

PERMISSIONS AND CLEARANCES

Permission to carry out the study was obtained from the Institutional Ethics Committee.

Open reduction and internal fixation for all patients were done under general anaesthesia with nasoendotracheal intubation. Individuals were informed about the nature of the study and their informed consent was taken before including them in the study. After completion of surgery all patients were prescribed Inj. Diclofenac sodium intravenous 75mg 8 hourly for the post-operative analgesia and Inj. Ondensetron- 4mg intravenous to prevent post-operative vomiting

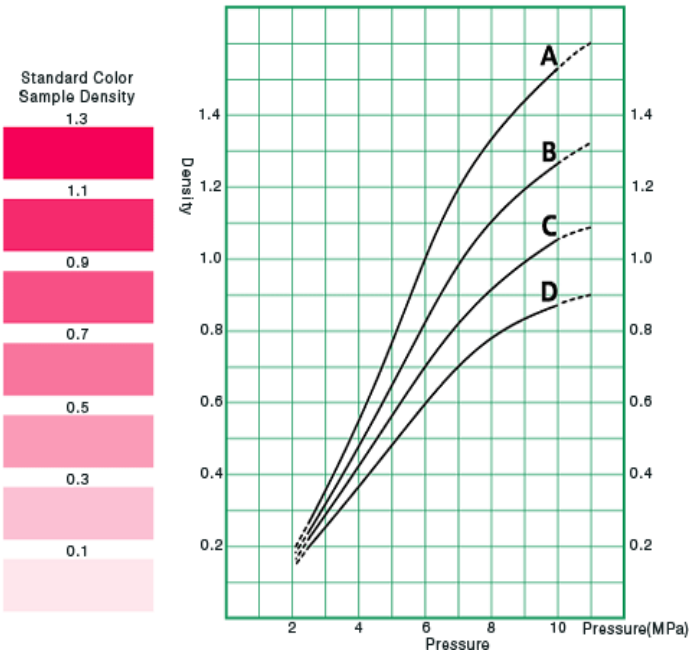
At the end of 2$^{nd\ 4th}$ and 6th post operative week bite forces of the patients were recorded in the right and left molar using Nupai bite scan analyser (Fuji^{TM})

Bite force measurement:

Bite force assessment was done with NUPAI PRE-SCALE film (FUJI^{TM}). It consisted of two films sandwitched over each other. One named A film also called ‘transfer sheet’ and the other C film also called ‘developer sheet’. This method of measuring bite force was chosen because the combined thickness of both the films is 200 micrometers, and hence it will not interfere in the physiologic occlusion of the teeth.

The A film has microcapsules containing dyes and C film is coated with developing agents. The films are placed such that the microcapsules of A film and the developer of C film face each other. The films are designed such that when there is application of external pressure to the sheets, the microcapsules of the A film is broken and stain the developer in C film in magenta. The distribution and density of the magenta colour depends on the magnitude of the pressure applied. Through PSC (particle size control) technology the microcapsules are designed to react to various degrees of pressure, releasing their colour forming material at a density that corresponds to the specific levels of pressure applied. Thus the prescale film can record the distribution of normal forces applied to it. Therefore this property of the prescale film is used to measure the overall maximal bite force generated post mandibular fracture treatment. It measured forces ranging from 35-350 psi.

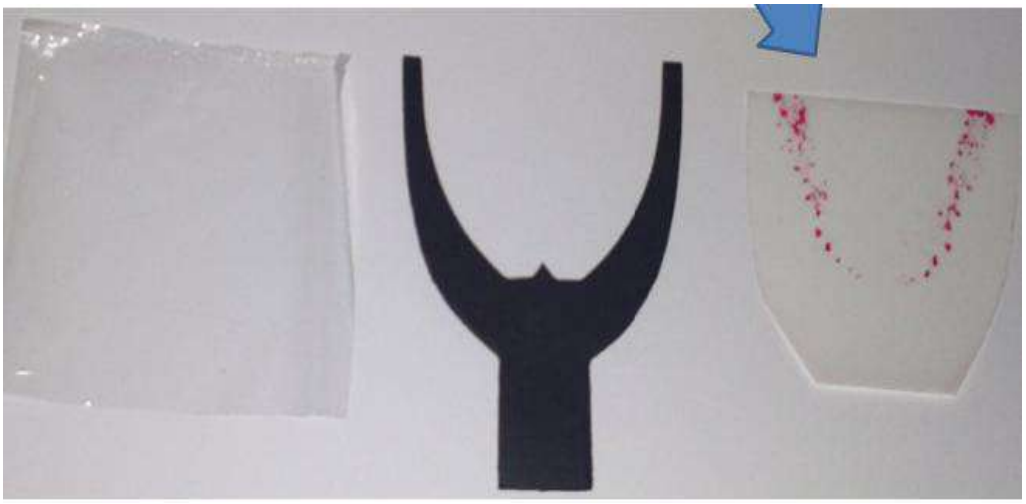
The whole assembly was covered with a water proof cellophane sheet, to prevent any chemicals from leaking out accidentally and injuring the patients. The patients were made to sit comfortably on a chair and were asked to bite on the loaded films, as assembled, with as much force as possible and maintain the same pressure for 5 seconds. The film changed colour depending on the amount of pressure applied. The colour change that took place was similar to the one shown in figure. The colour change in the film was analysed using the technique elaborated as follows.



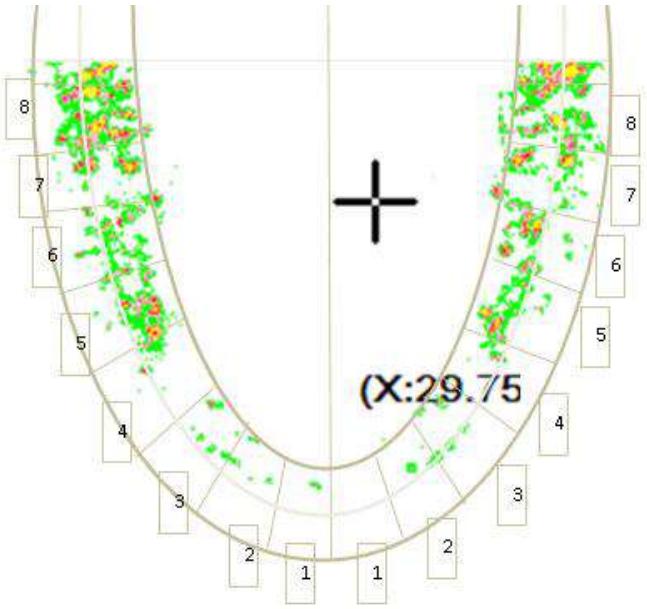
NUPAI bite analysis- assembly

Assembly placed in mouth

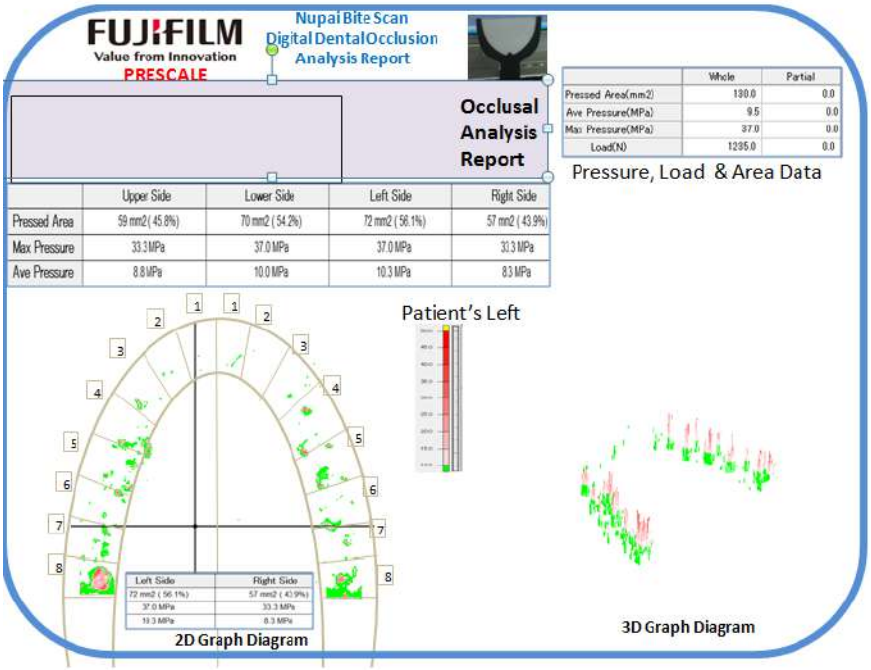
Patient is asked to bite on it for 5 seconds



Bite force prescale paper removed



Scanned image interpretation by software



Final bite scan report showing bite force measurements

With the values of pressure and the area, the force in the specified region is calculated using the formula

FORCE (in Newtons) = PRESSURE (in Pascal) X AREA (in Sq. Meter)

1. Mean: To obtain the mean, the individual observations were first added together and then divided by the number of observation. The operation of adding together or summation is denoted by the sign Σ.

The individual observation is denoted by the sign X, number of observation denoted by n, and the mean by $\overline{X}$.

$$\overline{X} = \frac{\Sigma X}{\text{No. of observations (n)}}$$

2. Standard Deviation: It is denoted by the Greek letter σ. If a sample is more than 30 then.

$$\sigma = \sqrt{\frac{\Sigma (X - \overline{X})^2}{n}}$$

When sample in less than 30 then.

$$\sigma = \sqrt{\frac{\Sigma (X - \overline{X})^2}{n-1}}$$

3. **Chi square test:**

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Where O = Observed frequency

E = Expected frequency

4. **Student 't' test**: To test the significance of two means the student 't' test was used

$$t = \frac{\overline{X}_1 - \overline{X}_2}{S\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

where $S^2 = \frac{(N_1 - 1)SD_1^2 + (N_2 - 1)SD_2^2}{N_1 + N_2 - 2}$

where $\overline{X}_1$, $\overline{X}_2$ are means of group 1 and group 2

N_1, N_2 are number of observation group1 and group 2

SD_1, SD_2 are standard deviation in group1 and group 2

5. **Level of significance**: "p" is level of significance

p > 0.05	Not significant
p <0.05	Significant
p <0.01	Highly significant
p <0.001	Very highly significant

OBSERVATIONS AND RESULTS

The present study was conducted in the Department of Plastic Surgery at Dayanand Medical College and Hospital, Ludhiana to study the bite force measurements I post operative patients of mandible fracture reduction.. All patients undergoing elective and emergency open reduction and internal fixation for mandible fracture fulfilling the inclusion criteria were included in the study. The criterias studied are as under:

Table 1: Age distribution of patients

Age group	No. of cases	Percentage
< 30	13	41.9%
31-40	11	35.5%
> 40	7	22.6%
Total	31	100.0%

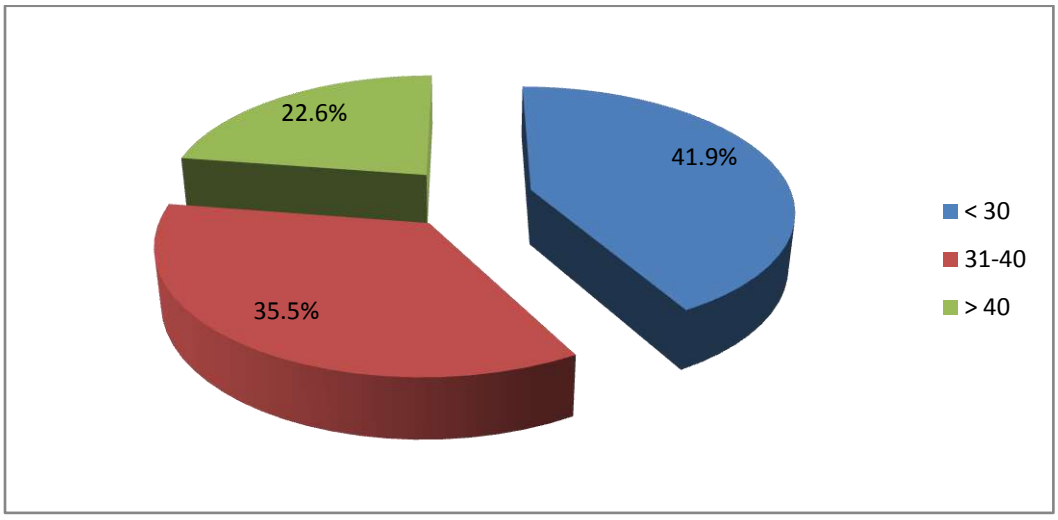


Figure 1: Age distribution of patients

A total of 31 patients were taken for the study 13 (41.9%) were in the age group <30 yrs, least percentage (22.6%) were in the age group >40 years

Table 2: Distribution according to sex

SEX	No. of cases	Percentage
F	4	12.9%
M	27	87.1%
Total	31	100.0%

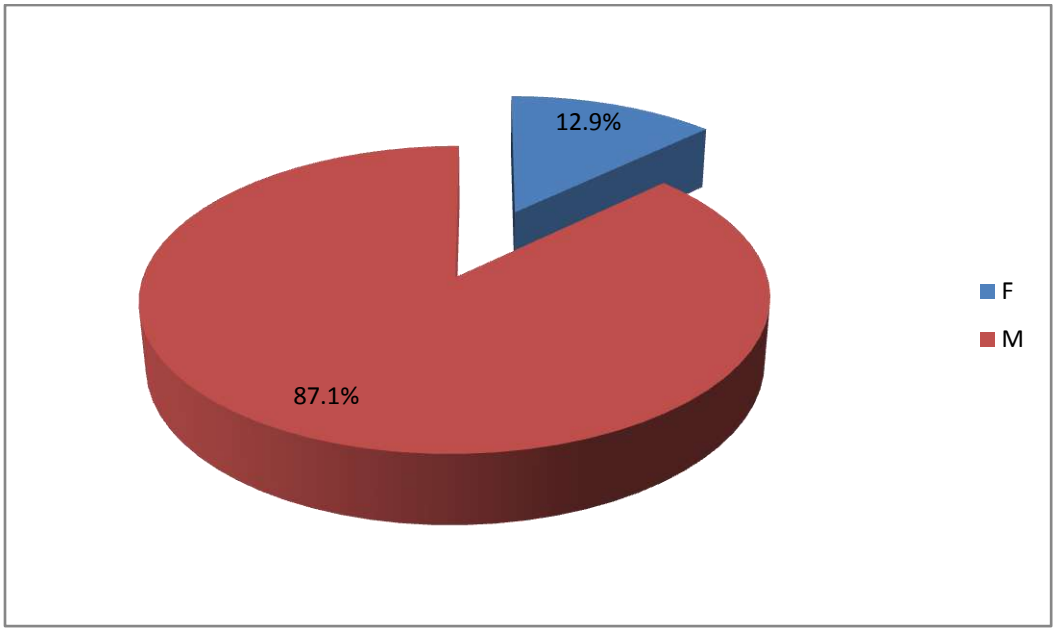


Figure 2: Distribution according to sex

Maority of the patients (87.1%) were of male sex, only 4 female patients (12.9%) were included in the study

Table 3: Distribution according to the mode of injury

MODE OF INJURY	No. of cases	Percentage
ASSAULT	3	9.7%
FALL	2	6.5%
RSA	26	83.9%
Total	31	100.0%

Most of the patients admitted for the same had history of road side accident (83.9%). Assault (9.7%) and history of fall (6.5%) accounted for rest of the cases

Table 4: History of oral bleed

ORAL BLEED	No. of cases	Percentage
ABSENT	23	74.2%
PRESENT	8	25.8%
Total	31	100.0%

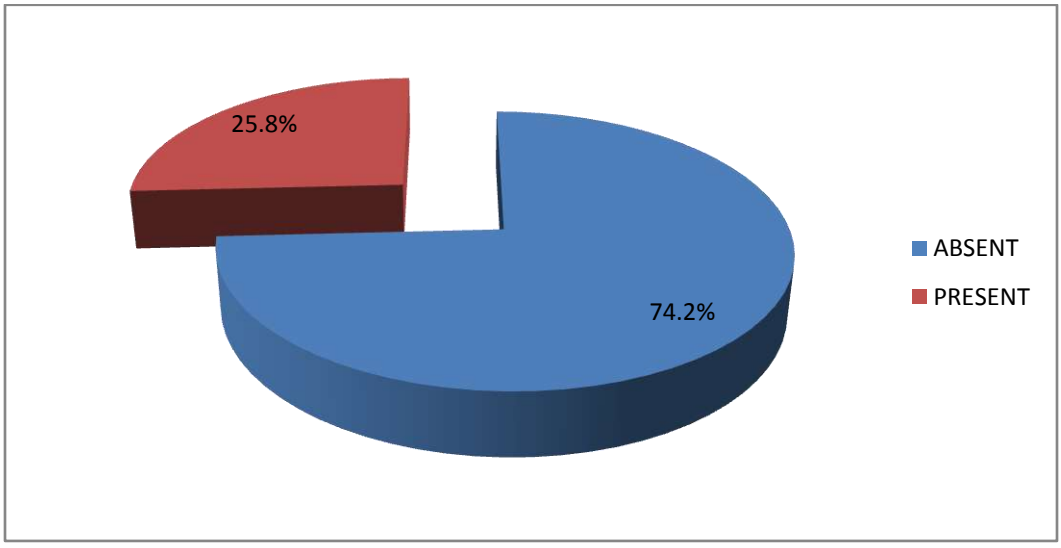


Figure 3: Distribution of history of oral bleed

History of oral bleed was absent in most of the patients (74.2%) while it was present in 25.8% of the patients.

Table 5: Associated comorbidities

COMORBIDITIES	No. of cases	Percentage
HEPATITIS C	2	6.5%
NIL	29	93.5%
Total	31	100.0%

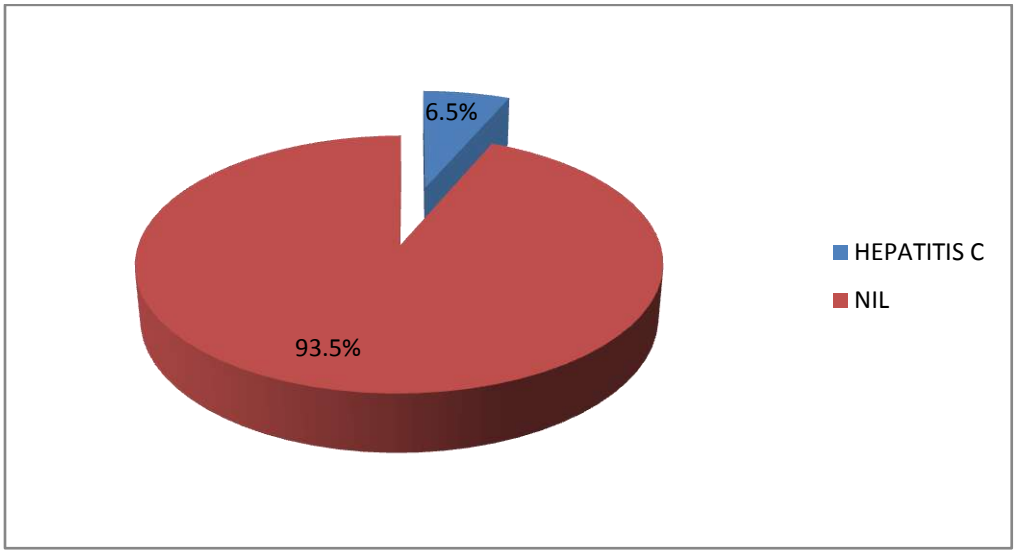


Figure 4: Associated co-morbidities

Hepatitis C was present in 2 of the patients (6.5%). Rest all the patients did not have any associated comorbidities.

Table 6: Presence of mandibular mobility

MOBILITY	No. of cases	Percentage
NO	17	54.8%
YES	14	45.2%
Total	31	100.0%

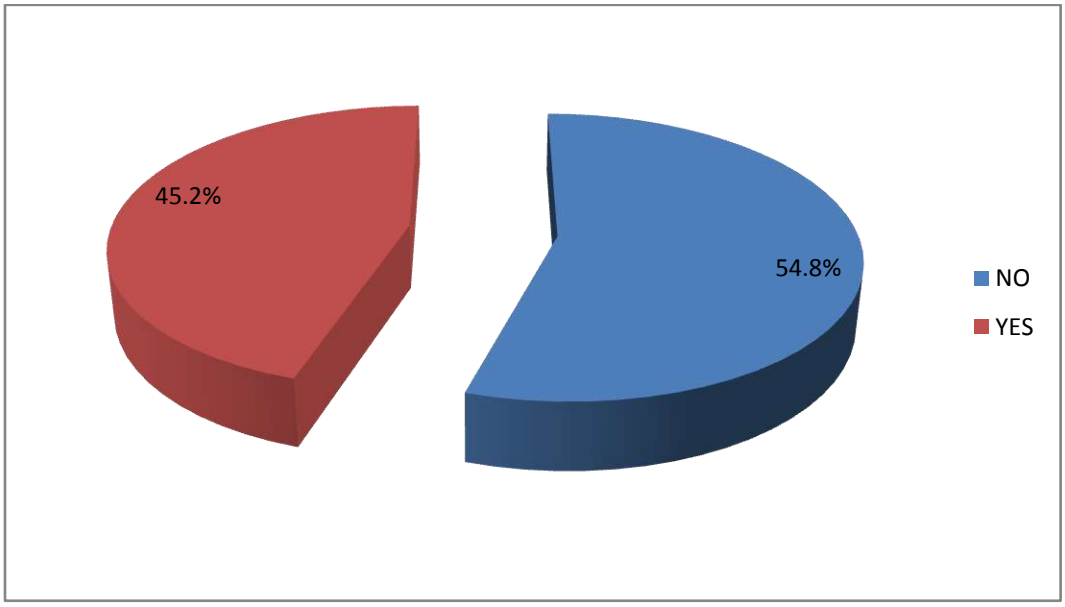


Figure 5: Distribution of mandiblar mobility

Mandibular mobility was positive in 45.2% patients (N=14) while it was absent in 54.8% of patients (N=17)

Table 7: Number of fractures

No. of factures	No. of cases	Percentage
Single	14	45.2%
Double	12	38.7%
Mulitple	5	16.1%
Total	31	100.0%

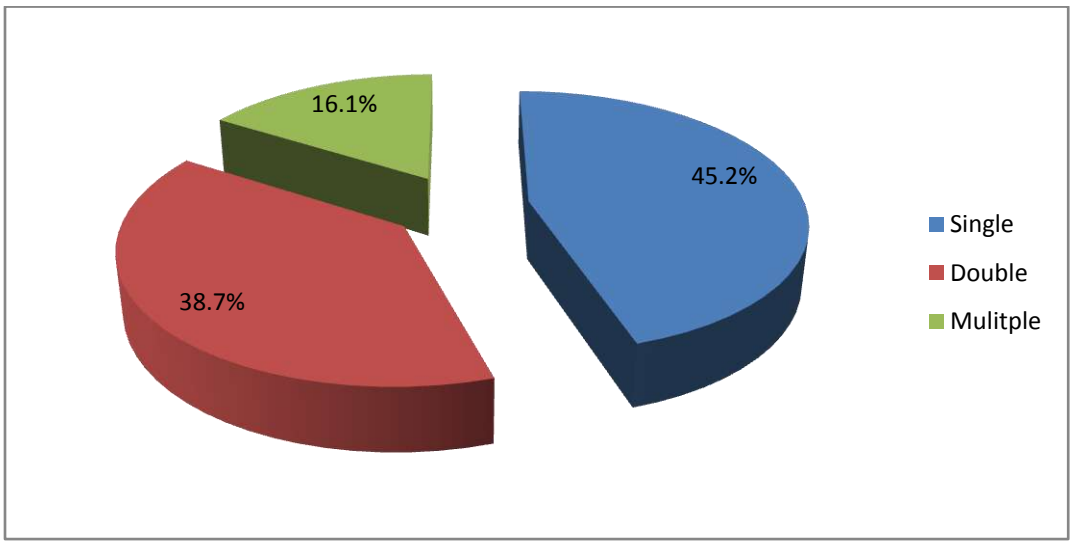


Figure 6: Distribution of number of fractures

Mostly we came across patients with single fracture (42.5%). Two fractures were seen in 12 patients (38.7%). More than 2 fractures were seen in 5 patients (16.1%)

Table 8: Types of fratures

DIAGNOSIS	No. of cases	Percentage
BL PARASYMPHYSIS	4	12.9%
BL PARASYMPHYSIS C SEGMENT	2	6.5%
BL PARASYMPHYSIS, BL SUB CONDYLE	1	3.2%
BL PARASYMPHYSIS,LT SUB CONDYLE	1	3.2%
BL PARSYMPHISIS,RT SUBCONDYLAR	1	3.2%
LT ANGLE	1	3.2%
LT BODY OF MANDIBLE	2	6.5%
LT PARASYMPHYSIS	5	16.1%
LT PARASYMPHYSIS, BL SUB CONDYLE	2	6.5%
RT ANGLE ,LT PARASYMPHYSIS	1	3.2%
RT BODY OF MANDIBLE	2	6.5%
RT PARASYMPHYSIS	3	9.7%
RT PARASYMPHYSIS, LT SUB CONDYLE	1	3.2%
RT PARASYMPHYSIS,LT BODY	2	6.5%
RT PARSYMPHYSIS, LT ANGLE	2	6.5%
SYMPHYSIS MANDIBLE	1	3.2%
Total	31	100.0%

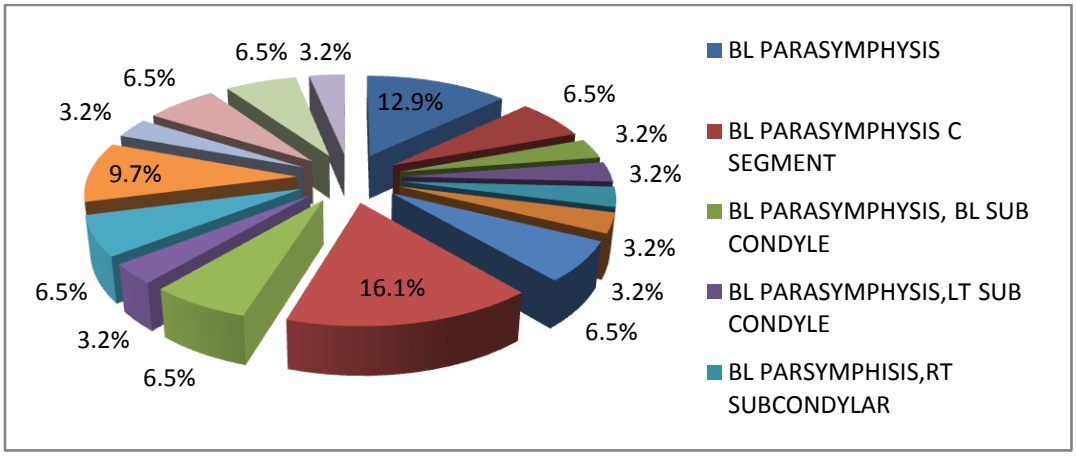


Figure 7: Distribution of the types of fractures

Leftl parasymphysis fracture was the most common type of fracture which we came across (16.1%).

Table 9: Site of fracture

	No. of cases	Percentage
PARASYMPHYSIS	25	80.6%
BODY	6	19.4%
ANGLE	4	12.9%
SUBCONDYLAR	6	19.4%
SYMPHYSIS MANDIBLE	1	3.2%

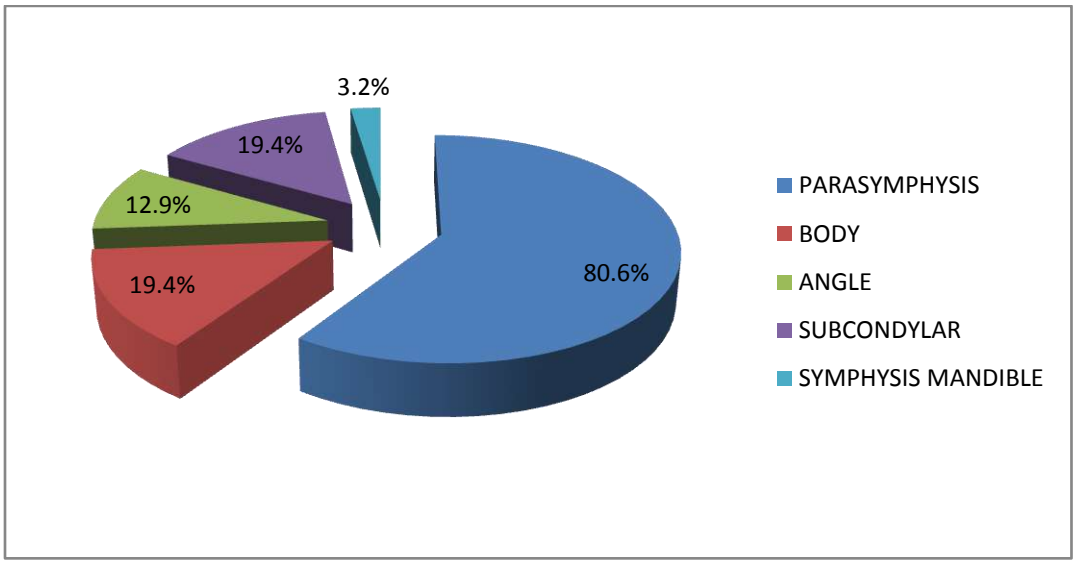


Figure 8: Distribution of the anatomical site of fracture

Parasymphyseal fracture was the most common site identified (80.6%). Body and angle of mandible fractures were of same frequency (19.4%). Angle of mandible facture was seen in 1.9% of patients. Symphysis of mandible fracture was seen in one patient (3.2%)

Table 10: Time duration from the date of injury to date of surgery

INTERVAL - DATE OF INJURY TO SURGERY	No. of cases	Percentage
1	11	35.5%
2	15	48.4%
3	3	9.7%
4	2	6.5%
Total	31	100.0%

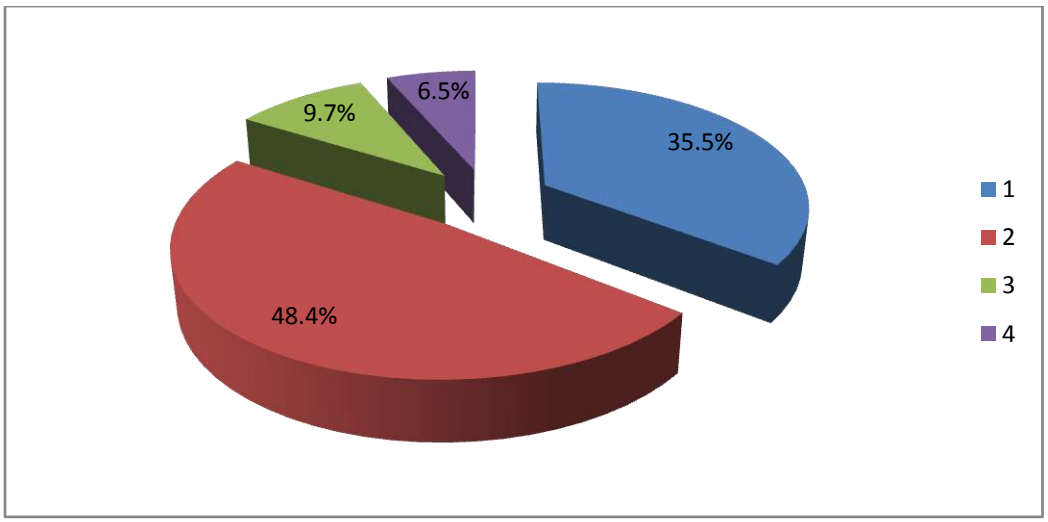


Figure 9: Duration from date of injury to surgery

Most of the patients got operated on the second day of injury (48.4%). 35.5% of patients underwent surgery on the first day of surgery. 9.7% of patients underwent surgery on third day of injury. 2 patients (6.5%) were operated on day 4 of the surgery.

Table 11: Approach for the surgical procedure

APPROACH	No. of cases	Percentage
EXTRAORAL	5	16.1%
INTRAORAL	26	83.9%
Total	31	100.0%

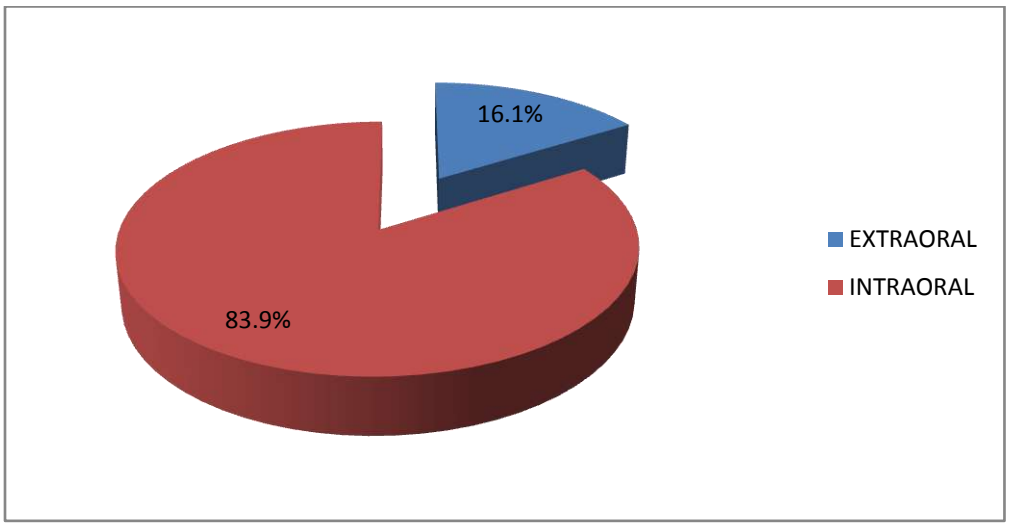


Figure 10: Distribution of surgical approach for ORIF

Angle of mandible fractures were approached through the extraoral approach (16.1%). Rest all the other cases were approached through the intraoral route (83.9%).

Table 12: Plating method

PLATING	No. of cases	Percentage
3 AND 4 HOLE PLATE WITH GAP	1	3.2%
4 AND 3 HOLE PLATE WITH GAP	3	9.7%
4 AND 3 HOLE PLATE WITH GAP WITH MMF	1	3.2%
4 HOLE PLATE WITH GAP	4	12.9%
6 HOLE PLATE WITH GAP,CURVED PLATE	1	3.2%
BL 4 HOLE AND 3 HOLE PLATE	1	3.2%
BL 4 HOLE PLATE WITH GAP	2	6.5%
BL 4 HOLE PLATE WITH GAP WITH MMF	1	3.2%
BL DOUBLE 4 HOLE PLATE	1	3.2%
BL TWO 4 HOLE PLATE WITH GAP WITH MMF	1	3.2%
LONG PLATE	1	3.2%
TWO 3 HOLE PLATE WITHOUT GAP WITH MMF	1	3.2%
TWO 4 HOLE PLATE WITH GAP	8	25.8%
TWO 4 HOLE PLATE WITH GAP ON BOTH SIDES	2	6.5%
TWO 4 HOLE PLATE WITH GAP,ANGLE TWO 3 HOLE	1	3.2%
TWO 4 HOLE PLATE WITHOUT GAP	1	3.2%
TWO 4 HOLE PLATE WITHOUT GAP, ANGLE NOT FIXED	1	3.2%
Total	31	100.0%

Table 13: Post operative maxillomandibular fixation

POST OP MMF	No. of cases	Percentage
DONE	19	61.3%
NOT DONE	12	38.7%
Total	31	100.0%

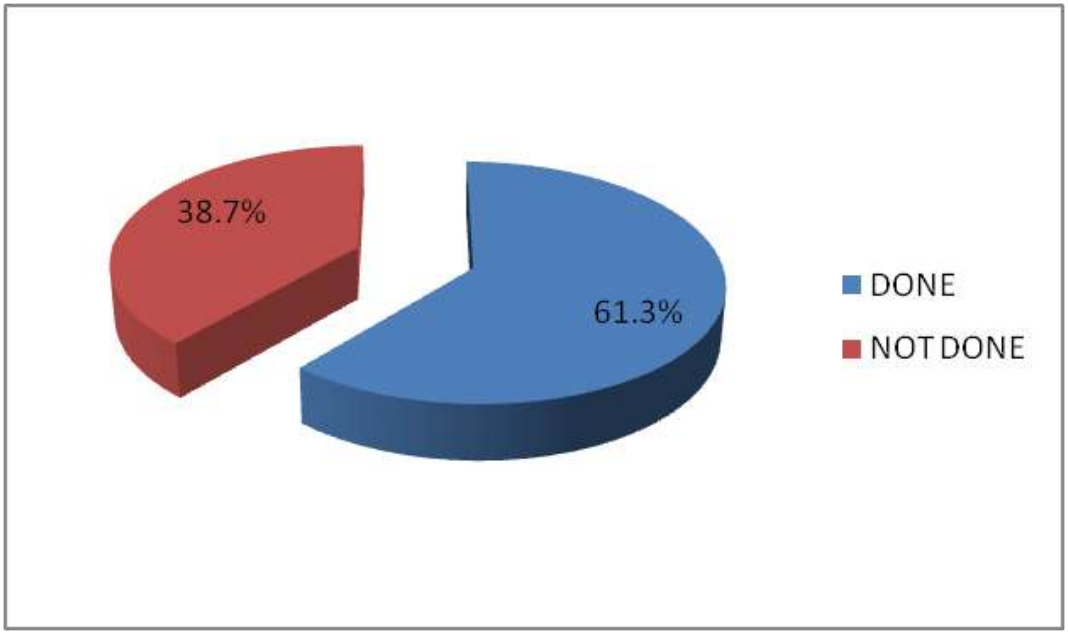


Figure 11: Distribution of post operative maxillomandibular fixation

Postoperative maxillomandiblar fixation was done in 19 patients(61.3%) while in 12 patients (38.7%) maxillomandibular fixation was not necessary

Table 14: Post operative pain (VAS score)

POST OP PAIN	No. of cases	Percentage
2	6	19.4%
3	11	35.5%
4	12	38.7%
5	2	6.5%
Total	31	100.0%

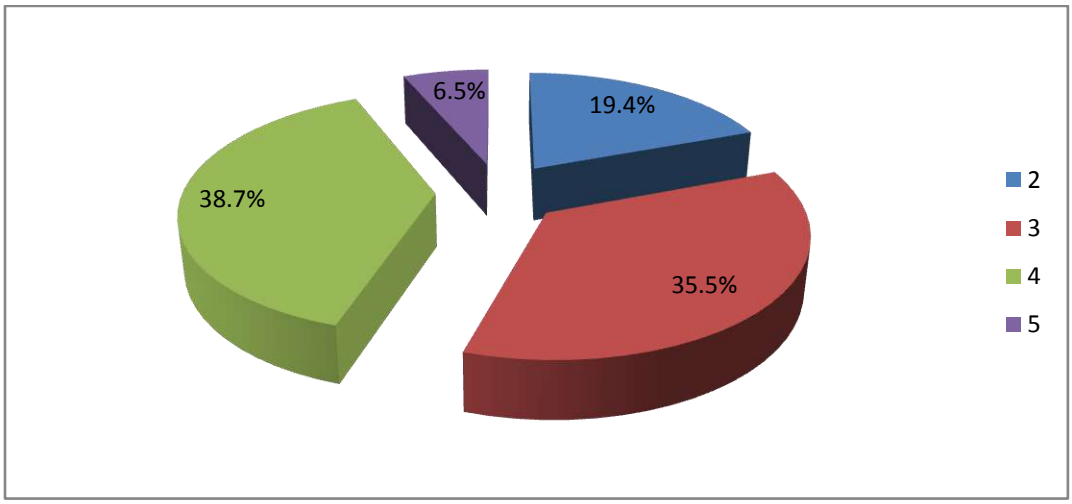


Figure 12: Distribution of pain according to VAS score post operatively

Most of the patients had a pain score of 4 according to visual analogue scale (38.7%). The second most common was pain score of 3 (35.5%)

Table 15: Post operative chewing ability (VAS score 0-10 in increasing order of normal bite function)

POST OP CHEWING	No. of cases	Percentage
3	1	3.2%
4	6	19.4%
5	24	77.4%
Total	31	100.0%

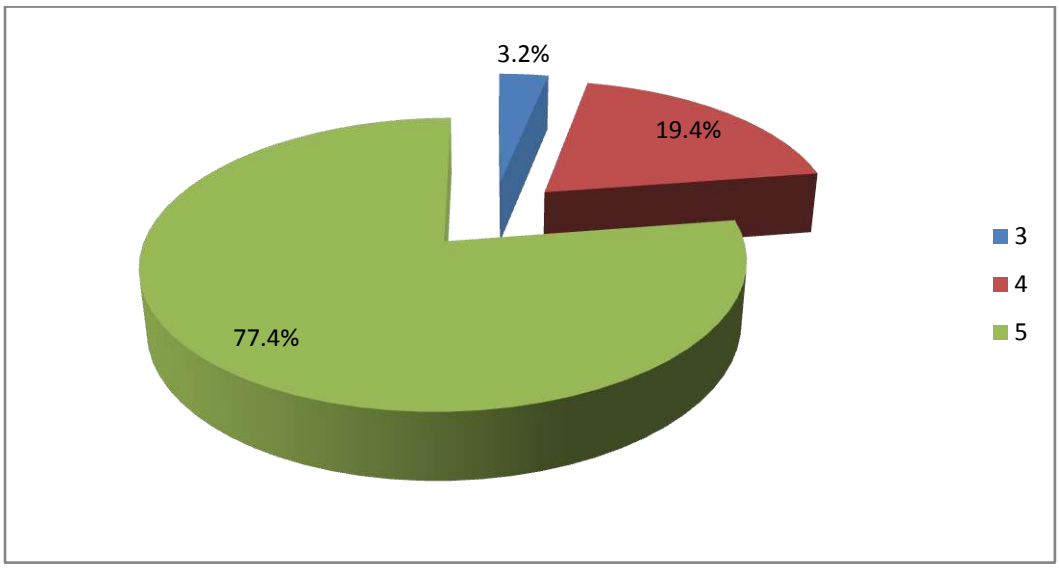


Figure 13: Post operative chewing ability (VAS score 0-10 in increasing order of normal bite function)

Most of the patients demonstrated a chewing function of 5 (VAS scale) 77.4%.

Table 16: Post operative complications

COMPLICATION	No. of cases	Percentage
PARESTHESIA	4	12.9%
MALOCCLUSION	2	6.5%
SSI	2	6.5%
NIL	23	74.2%
Total	31	100.0%

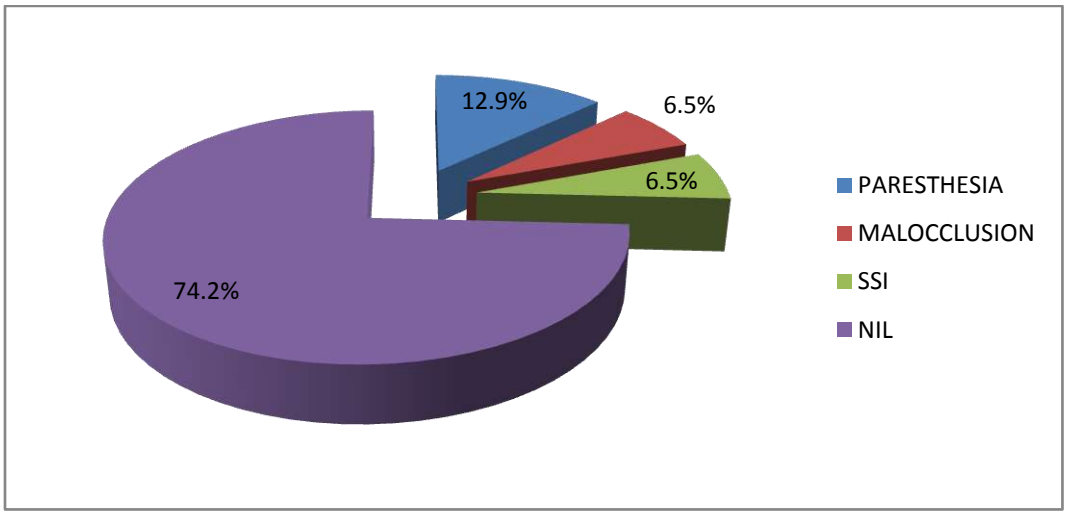


Figure 14: Distribution of post operative complications

Most of the patients did not demonstrate any post operative complications (74.2%). Paresthesia was seen in 4 of the patients (12.9%). Malocclusion and surgical site infection were seen in 2 patients each (6.5%).

Table 17: Correlation between various factors and post op bite force

AGE	31	20.0	48.0	33.7	8.3
INTERVAL -DATE OF INJURY TO SURGERY	31	1.0	4.0	1.9	0.8
POST OP PAIN	31	2.0	5.0	3.3	0.9
POST OP CHEWING	31	3.0	5.0	4.7	0.5
BITE FORCE 2R	31	121.0	142.0	134.5	5.4
BITE FORCE 2L	31	120.0	143.0	133.0	5.2
BITE FORCE 4R	31	148.0	179.0	164.0	8.4
BITE FORCE 4L	31	145.0	182.0	164.3	9.2
BITE FORCE 6R	31	171.0	206.0	193.1	8.0
BITE FORCE 6L	31	176.0	209.0	192.6	8.0
Difference at 4week R	31	11.8	34.1	22.1	6.0
Difference at 4week L	31	11.6	34.4	23.6	6.5
Difference at 6week R	31	34.8	52.3	43.7	4.5
Difference at 6week L	31	37.4	53.1	44.9	4.5

There was a definite trend in improvement of bite force when the time duration between injury and surgery was less. Bite force improvement was seen but the difference was no statistically significant

Table 18: Correlation between number of fractures and post op bite force

	No. of factures	N	Mean	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum	F	p-value
					Lower Bound	Upper Bound				
Difference at 4week R	Single	14	22.4	7.5	18.0	26.7	11.8	34.1	0.255	0.777
	Double	12	21.2	4.3	18.4	23.9	14.0	28.8		
	Multiple	5	23.3	5.7	16.3	30.4	14.2	28.8		
	Total	31	22.1	6.0	19.9	24.3	11.8	34.1		
Difference at 4week L	Single	14	22.7	7.2	18.5	26.8	11.6	34.4	0.424	0.659
	Double	12	25.0	6.1	21.1	28.9	13.2	33.3		
	Multiple	5	23.1	5.9	15.7	30.4	15.9	31.9		
	Total	31	23.6	6.5	21.2	26.0	11.6	34.4		
Difference at 6week R	Single	14	44.9	5.0	42.0	47.7	34.8	52.2	1.7	0.201
	Double	12	41.8	3.5	39.6	44.1	35.3	47.8		
	Multiple	5	44.8	4.7	39.0	50.7	40.3	52.3		
	Total	31	43.7	4.5	42.0	45.3	34.8	52.3		
Difference at 6week L	Single	14	44.5	5.2	41.4	47.5	37.4	53.1	0.321	0.728
	Double	12	45.8	4.0	43.2	48.3	40.4	53.0		
	Multiple	5	44.3	4.3	39.0	49.5	37.9	49.3		
	Total	31	44.9	4.5	43.3	46.6	37.4	53.1		

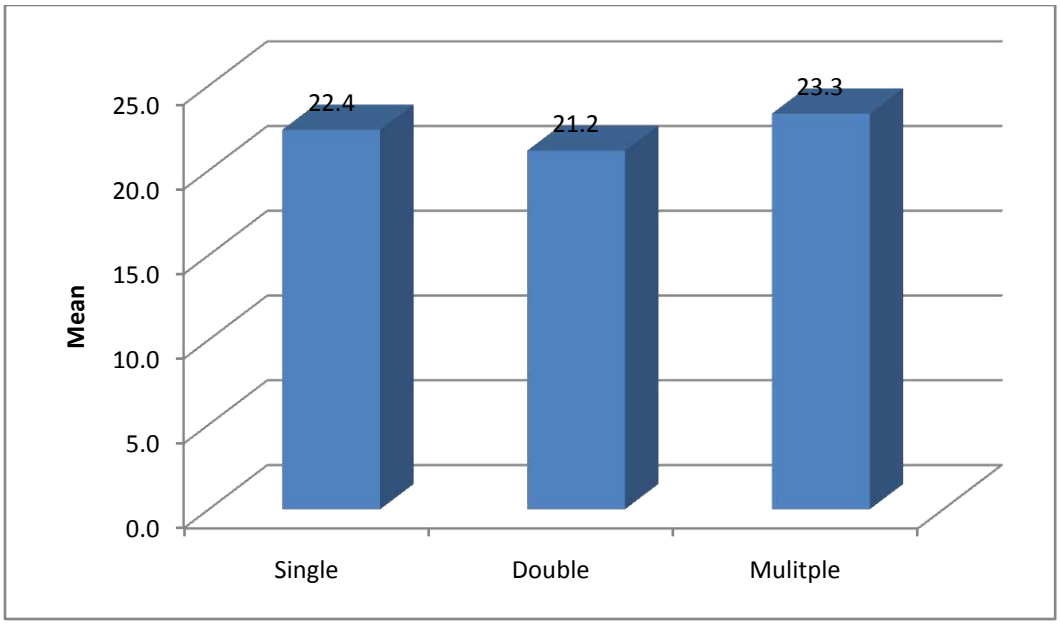


Figure 15: Correlation between number of fractures and Difference at 4 week Rt

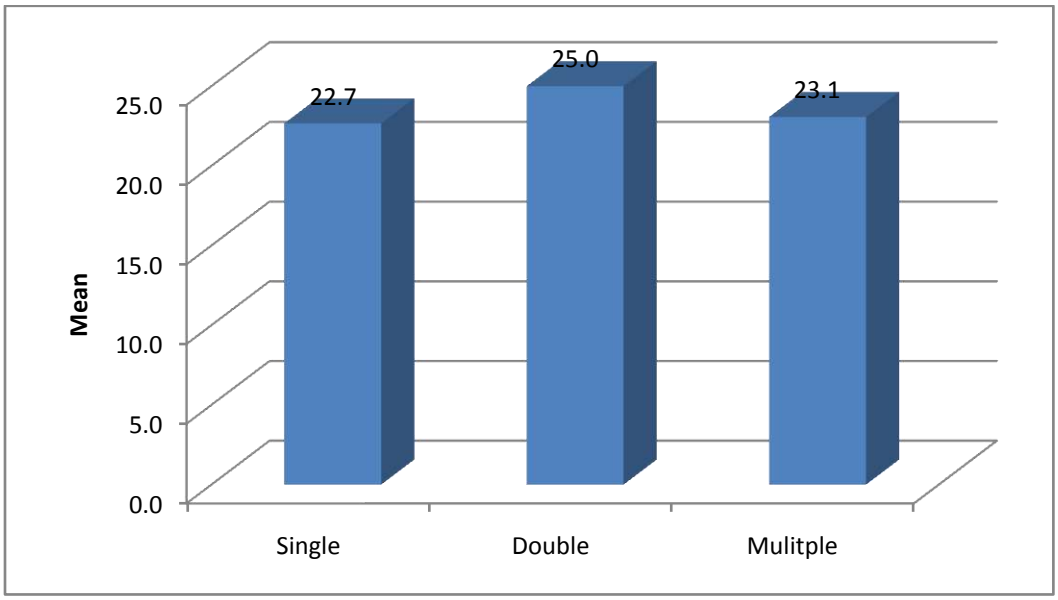


Figure 16: Correlation between number of fractures and Difference at 4week Lt

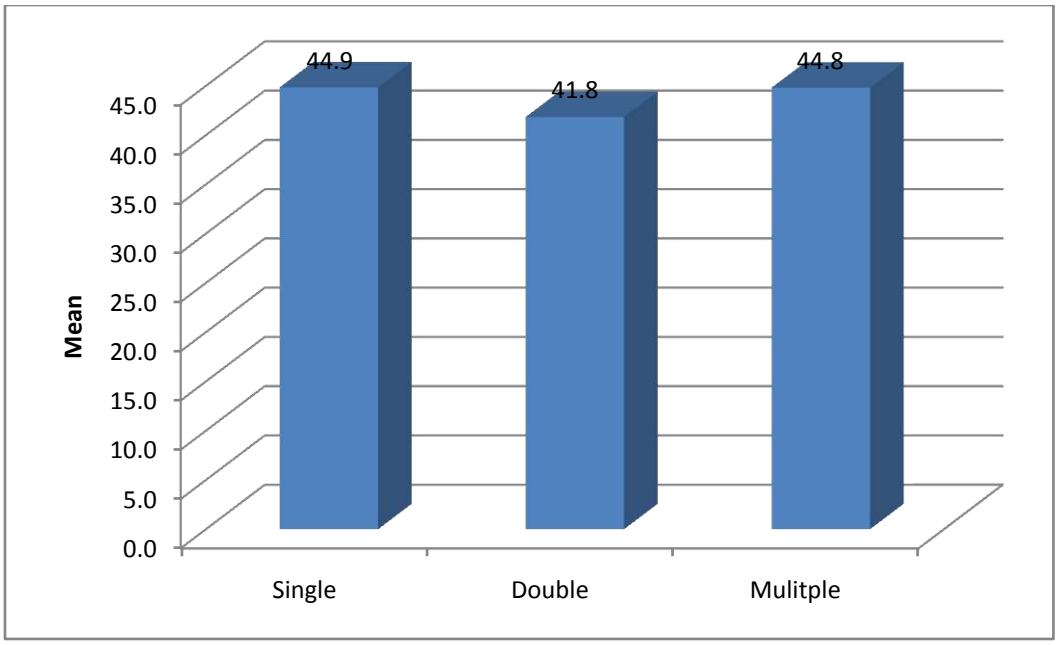


Figure 17: Correlation between number of fractures and Difference at 6week Rt

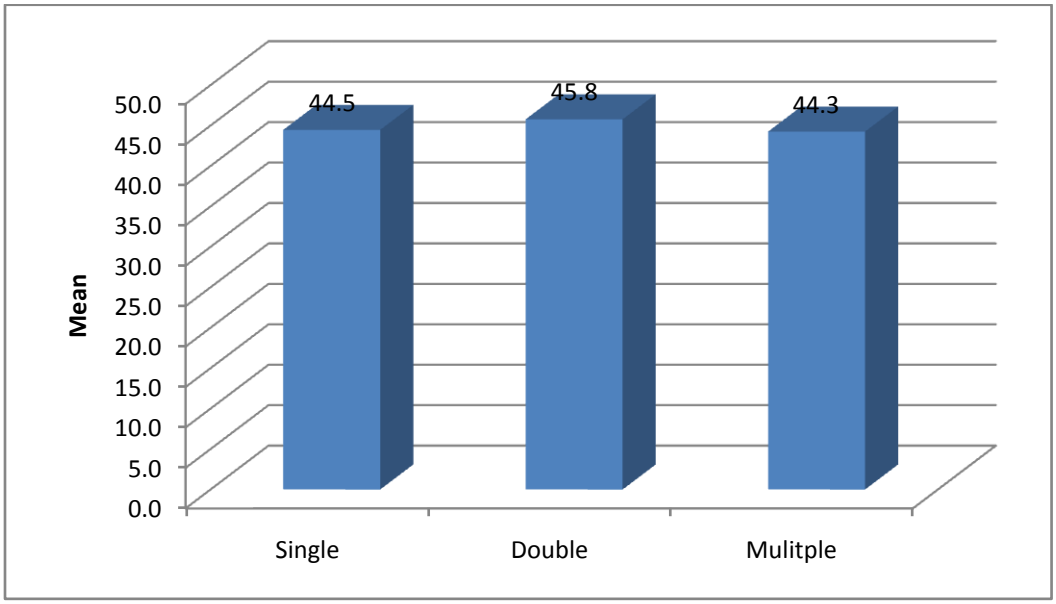


Figure 18: Correlation between number of fractures and Difference at 6week lt

There was a definite improvement in the bite force of the patients, at 4 week and 6 week interval of either side. This difference was not dependent upon the site and number of fracture. The increase is demonstrated but statistically not significant.

Table 19: Correlation between injury to surgery interval and post op bite force

INTERVAL -DATE OF INJURY TO SURGERY		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	F	p-value
						Lower Bound	Upper Bound				
Difference at 4week R	1	11	23.9	5.0	1.5	20.6	27.3	14.2	30.2	2.519	0.079
	2	15	22.8	6.3	1.6	19.2	26.3	11.8	34.1		
	3	3	16.5	4.2	2.4	6.0	26.9	12.1	20.4		
	4	2	15.0	2.2	1.5	-4.5	34.5	13.5	16.6		
	Total	31	22.1	6.0	1.1	19.9	24.3	11.8	34.1		
Difference at 4week L	1	11	24.5	5.7	1.7	20.7	28.3	15.4	34.4	2.355	0.094
	2	15	25.1	6.4	1.7	21.6	28.7	11.6	33.3		
	3	3	18.8	7.2	4.1	1.0	36.6	13.2	26.9		
	4	2	15.0	0.4	0.3	11.8	18.1	14.7	15.2		
	Total	31	23.6	6.5	1.2	21.2	26.0	11.6	34.4		
Difference at 6week R	1	11	44.9	4.3	1.3	42.0	47.7	39.4	52.2	1.16	0.343
	2	15	43.7	4.7	1.2	41.2	46.3	35.3	52.3		
	3	3	39.4	4.2	2.4	28.9	50.0	34.8	43.1		
	4	2	43.2	4.1	2.9	6.4	80.0	40.3	46.1		
	Total	31	43.7	4.5	0.8	42.0	45.3	34.8	52.3		
Difference at 6week L	1	11	44.1	4.5	1.4	41.0	47.1	37.9	53.1	0.421	0.739
	2	15	45.5	4.8	1.3	42.8	48.2	37.4	53.0		
	3	3	46.5	4.4	2.5	35.5	57.4	43.7	51.5		
	4	2	43.0	4.4	3.1	3.0	83.0	39.9	46.2		
	Total	31	44.9	4.5	0.8	43.3	46.6	37.4	53.1		

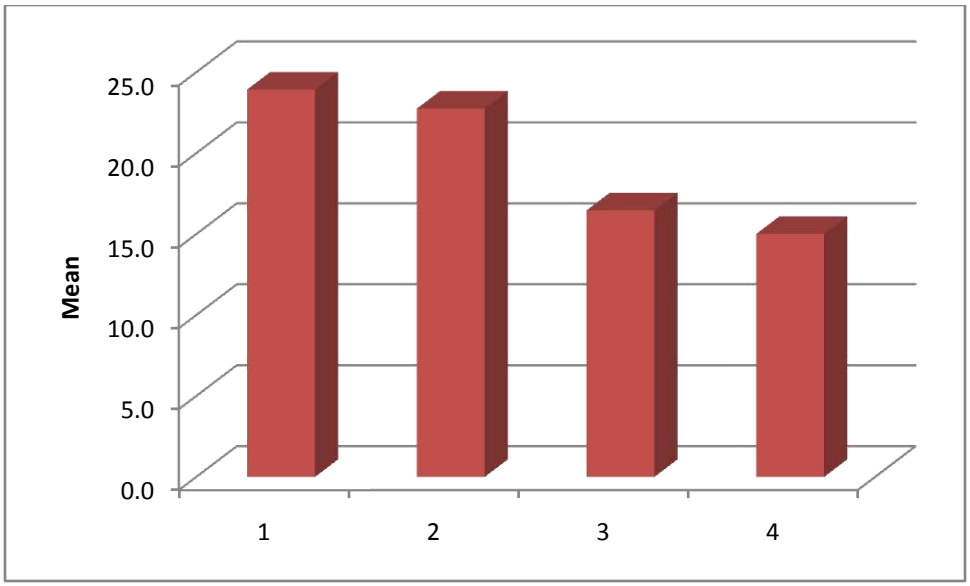


Figure 19: Correlation between injury to surgery interval and Difference at 4week Rt

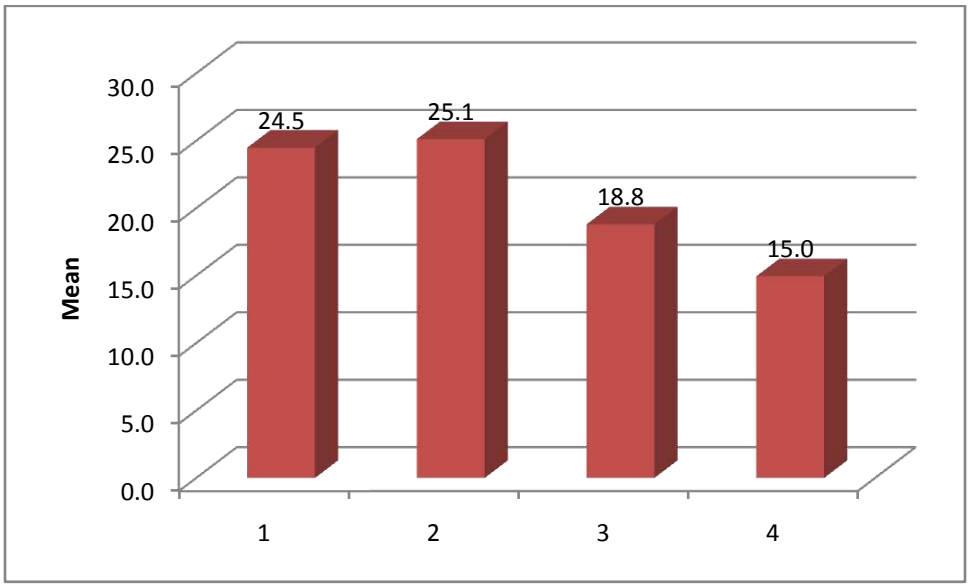


Figure 20: Correlation between injury to surgery interval and Difference at 4week lt

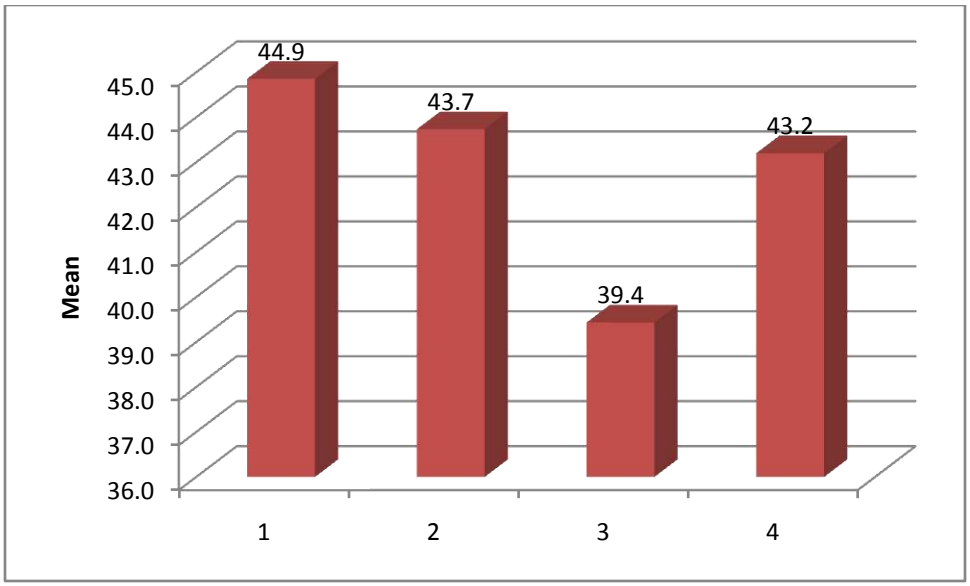


Figure 21: Correlation between injury to surgery interval and Difference at 6week Rt

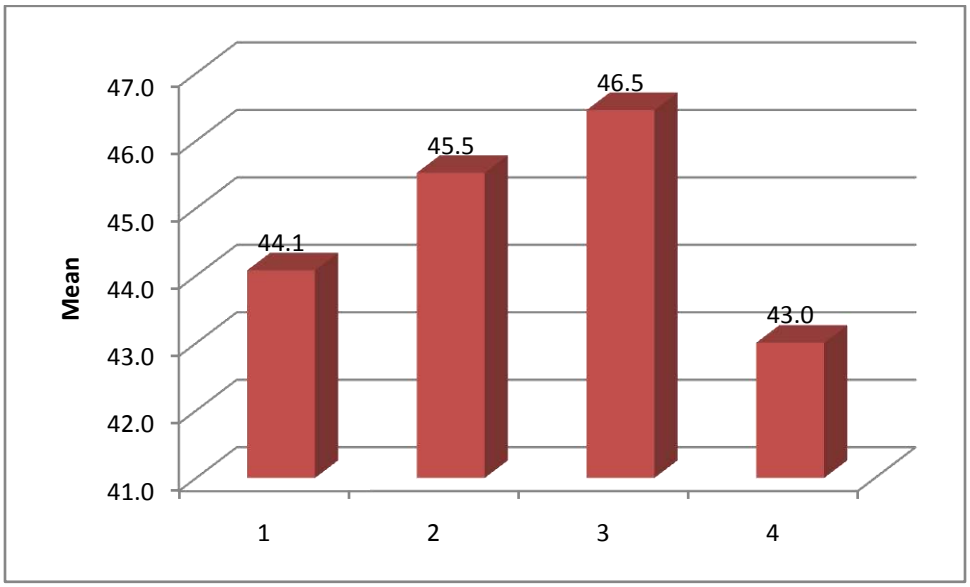


Figure 22: Correlation between injury to surgery interval and Difference at 6week lt

Decresed injury to surgery time improved the bite force but the improvement is not statistically significant.

Table 20. Parasymphysis fracture and post op bite force recovery

PARASYMPHYSIS	No		Yes		t	p-value	95% Confidence Interval of the Difference	
	No	SD	Yes	SD			Lower	Upper
Difference at 4week R	22.5	9.0	22.0	5.5	0.172	0.865	-5.6	6.6
Difference at 4week L	20.8	4.9	24.2	6.7	-1.074	0.292	-9.9	3.1
Difference at 6week R	44.7	6.3	43.5	4.2	0.556	0.583	-3.3	5.8
Difference at 6week L	44.3	3.8	45.1	4.7	-0.316	0.754	-5.3	3.9

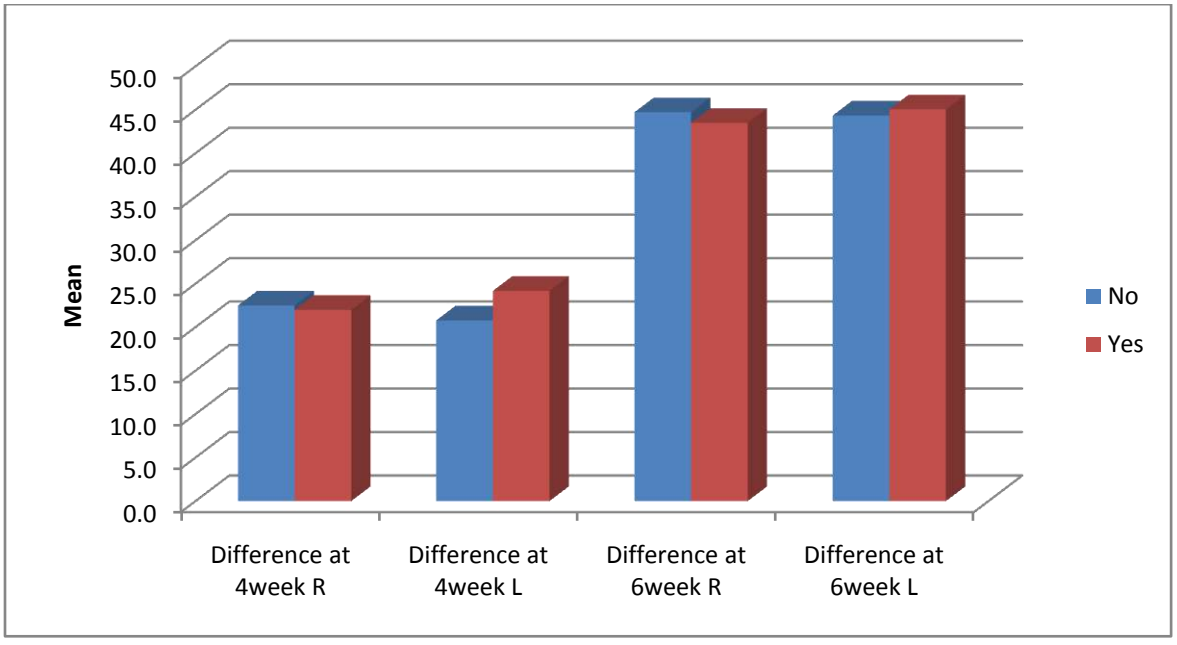


Figure 23. Parasymphysis fracture and post op bite force recovery

Improvement of bite force was seen in parasymphysis fracture. But the improvement was not statistically significant on either side.

Table 21: Body of mandible fracture – improvement in bite force

BODY	No		Yes		t	p-value	95% Confidence Interval of the Difference	
	No	SD	Yes	SD			Lower	Upper
Difference at 4week R	21.4	5.9	24.9	6.3	-1.299	0.204	-9.1	2.0
Difference at 4week L	23.2	6.6	25.2	6.4	-0.662	0.513	-8.1	4.1
Difference at 6week R	43.3	4.6	45.1	4.4	-0.874	0.389	-6.0	2.4
Difference at 6week L	45.0	4.8	44.6	3.4	0.202	0.841	-3.9	4.7

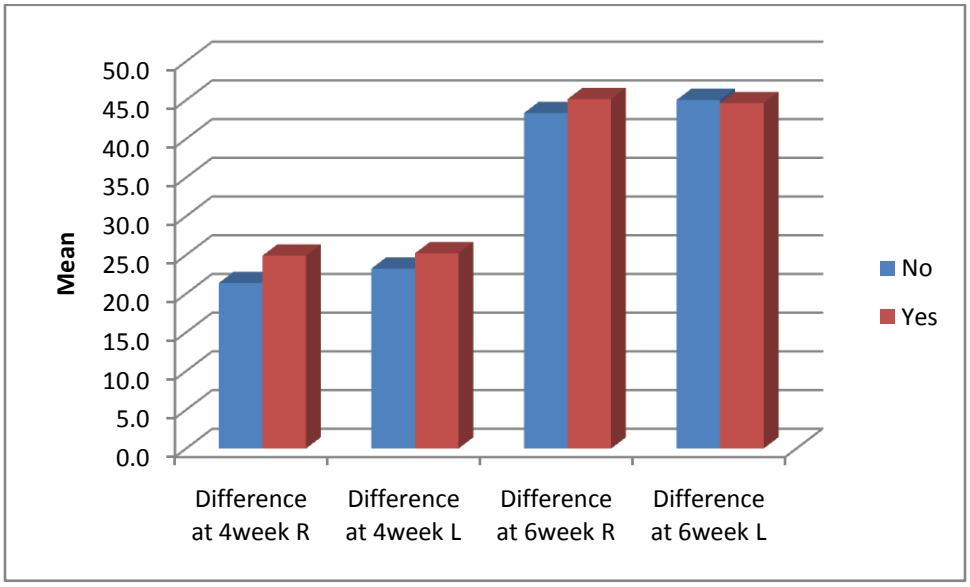


Figure 24: Body of mandible fracture – improvement in bite force

Bite force improvement was seen in cases of body of mandible fractures. But the improvement was not statistically significant.

Table 22: Angle of mandible fractures compared in improvement of bite force

ANGLE	No		Yes		t	p-value	95% Confidence Interval of the Difference	
	No	q	Yes	SD			Lower	Upper
Difference at 4week R	22.6	6.0	18.5	5.5	1.285	0.209	-2.4	10.7
Difference at 4week L	23.7	6.5	23.0	7.3	0.195	0.847	-6.5	7.9
Difference at 6week R	44.0	4.4	41.4	5.4	1.086	0.286	-2.3	7.6
Difference at 6week L	44.7	4.5	46.4	5.5	-0.689	0.496	-6.7	3.3

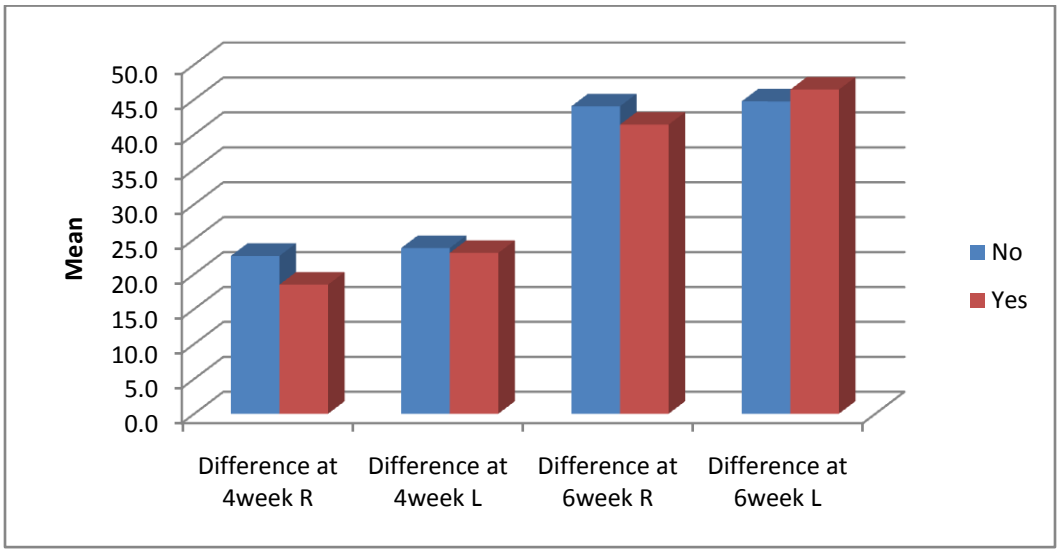


Figure 25: Angle of mandible fractures compared in improvement of bite force

Bite force improvement was seen in cases of angle of mandible fractures. This improvement was however not statistically significant

Table 23: Subcondylar fractures and bite force improvement

SUBCOND-YLAR	No		Yes		t	p-value	95% Confidence Interval of the Difference	
	No	SD	Yes	SD			Lower	Upper
Difference at 4week R	21.9	6.3	22.6	5.4	-0.246	0.807	-6.4	5.0
Difference at 4week L	23.7	6.8	23.2	5.3	0.162	0.872	-5.6	6.6
Difference at 6week R	43.6	4.6	43.9	4.8	-0.140	0.889	-4.6	4.0
Difference at 6week L	45.2	4.7	43.9	3.9	0.596	0.556	-3.0	5.5

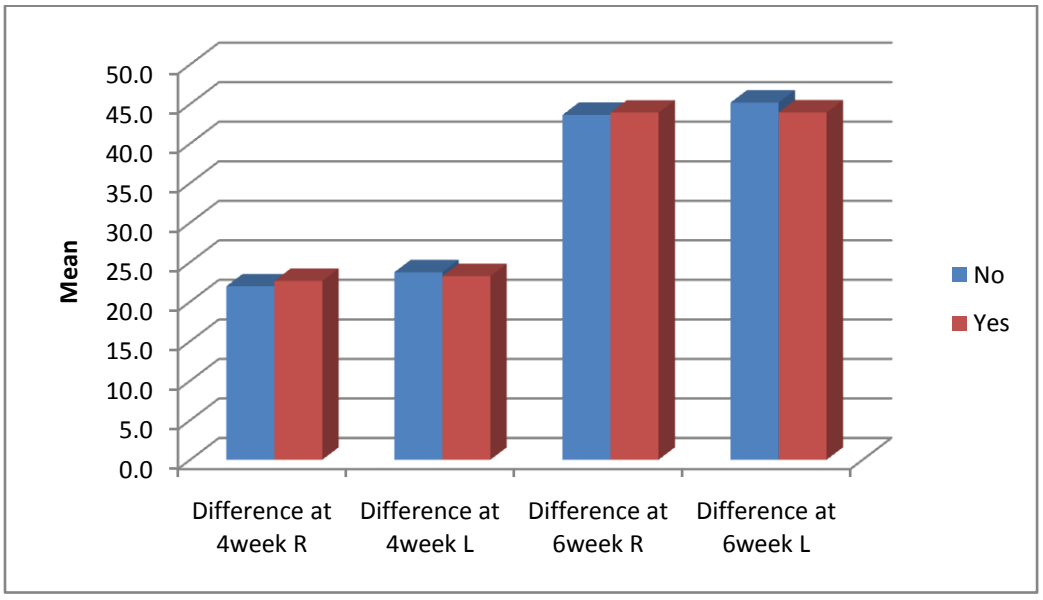


Figure 26: Subcondylar fractures and bite force improvement

Bite force improvement in case of subcondylar fracture was less as compared to all the fractures. This deficit was however no statistically significant

DISCUSSION

The art of surgery demands that we evaluate the risk and benefits of each treatment modality and apply it appropriately to each patient. There are a vast variety of treatment modalities for managing mandibular fractures and it remains imperative that we should consider the anatomic, physiologic and biomechanical factors associated with managing these injuries.

Bone healing is optimized by precise anatomic reduction and rigid immobilization. Once fractures are reduced and immobilized optimal bone repair is dependant on preservation and maintenance of sterile environment and intact blood supply. Movement of fractures causes disruption of the osteogenic elements and capillaries. This results in formation of poorly vascularized fibrous tissue which gives rise to complications in fracture healing like fibrous union or sometimes even non-union.

The earliest known writing on mandibular fractures appeared in Egyptian Papyrus from 1650 BC. Then fracture mandible was thought to be incurable and hence the patient was not treated and left to die. Hippocrates, the “father of medicine” was the first to describe the basic principle of modern fracture repair, reduction and stabilization.

Closed reduction of mandibular fracture was introduced by Chopart in 1795 when he used dental prosthetic device to immobilize the fractured segments. The concept of mandibular fixation was introduced by Salicett but was unheard of for centuries until Gilmer reintroduced it in United States in 1887.

The concept of closed reduction has a multitude of disadvantages like disturbance in phonation, nutritional problems, poor oral hygiene, compromised airway and social inconvenience. Moreover in certain clinical situations maxillomandibular fixation is either contraindicated or undesirable e.g. in epilepsy, patients with poly trauma, pregnancy, mentally challenged etc.

Surgeons began to explore the concept of open reduction and internal fixation. Techniques used in orthopaedic fracture management (Arbeitsgemeinschaft fur osteosynthesefragen / Association for study of internal fixation) (AO/ASIF), were borrowed and applied in maxillofacial surgery. Various techniques like intraosseous wires, external pins, intramedullary pins and plates and screws were tried by various experts. With advances in our understanding of bone healing after fracture, there has been a transformation from anatomic fixation principle to a more biomechanical fixation principle.

In 1973 Michelet and later in 1978 Champy and co-workers introduced non-compression miniplates in the treatment of mandibular fractures to overcome the disadvantages of the bulkier and technique demanding compression plating systems.

The pioneer biomechanical studies were again from Champy et al (1976) wherein he studied the photo elastic models of mandible and defined the lines of tension and compression. Based on these observations he outlined the ideal lines of osteosynthesis. Champy outlined the zones of ideal osteosynthesis in the mandible and described the specific areas of mandible for placement of bone plates to overcome the displacing forces acting on the mandible. The advantages of the mini plate osteosynthesis are: Smaller plates, easily adaptable with monocortical screw. Intraoral approach can be used with no scar formation, occlusal discrepancies are reduced, thereby reducing patient discomfort.

Though clinically successful, many surgeons like Raveh, Luhr, AO/ASIF advocates felt that these plates do not offer sufficient resistance to fracture fragment displacement. Hence they used supplemental maxillomandibular fixation for several weeks following fixation with mini plates. Two mini plate fixation technique for mandibular angle fracture was suggested to resist the adverse effects of chewing and loading in the fracture region. The study also showed that single plate fixation technique

as suggested by Champy showed inadequate stability following fracture site loading.[12]

But these results and observations were based on studies that considered the effects of maximum voluntary bite forces in non-injured subjects on fractured segments, in non-clinical models. It has been shown in many studies that the bite force remains significantly less, than those observed in non-injured individuals, even after 4 weeks following surgery.

Electrical and mechanical instruments like transducers, strain gauges, spring loaded appliances and chemical products like pre-scale film, which were used in medical field for measuring pressure were introduced in maxillofacial surgery as well. Advancement in technologies made it possible to reduce the size of these electrical and mechanical instruments and made the measurement of force or pressure more easy and reliable without causing any harm to the patients.

Measuring bite forces to evaluate treatment modalities became increasingly popular. It is being applied for

- Measuring functional outcome after fracture reduction.
- Measuring bite forces and contact areas before and after distraction osteogenesis.
- Evaluating the functional outcome in denture wearers
- Evaluating the functional outcome in implant retained prosthesis wearers
- Measuring level of comfort after periodontal surgeries
- As an aid to diagnosis for complicated orthodontic cases and thus plan further management.

The dental pre-scale film developed by Fuji – Japan in 1977, has gained wide acceptance for measuring bite forces in recent years. The miniature size and simplicity of its use are the two main contributing factors for its increasing popularity.

Various authors have preferred the use of pre-scale films to transducers for the following reasons.

- Patient not exposed to any electrical circuits
- Miniature size
- Recording bite forces in near physiologic position
- Occlusal contact at different places in the arch can be measured at the same point of time.

The average recommended period of immobilization of fractured mandible is 4-6 weeks. Although this is only empirical, it is usually influenced by several factors such as age of patient, type, number and severity of fracture, presence or otherwise of retained teeth in fracture line, and presence or absence of infection amongst others.

Study by K.L Gerlach et al shows regain in the maximal bite force values from 31% at the end of first post operative week to 58% at the end of fourth post operative week.[16]

Hence this criterion was chosen to compare the biomechanical efficacy of titanium conventional mini plates and titanium locking mini plates. Dental pre- scale film was chosen for measuring the bite forces for the above quoted reasons and it has been proven to give results similar to that when transducers or strain gauges were used.

Our study was done on study groups comprising of 31 patients, comparing bite force measurement increment in 2 weeks interval. However the results were not statistically significant. It may be due to small sample size or individual characteristics of the patients

- Pain
- Protective reflex mechanism known as “Muscle Splinting”, that occurs following fracture of bones. The neuromuscular system is activated or de- activated accordingly to take forces off the damaged skeleton.
- Traumatic and surgical damage caused to the muscle during injury and surgery respectively.

The findings of present study show that within standard post-operative bite foce assessment protocol mean bite force showed increase in all types of fractures, however the increase was not statistically

significant. The present study was an attempt to evaluate and compare the post operative bite forces in mandible fracture patients. A more elaborate study on more number of patients with a longer period of follow up is required.

SUMMARY AND CONCLUSION

The present study was conducted in the Department of Plastic Surgery at Dayanand Medical College and Hospital, Ludhiana to study bite force measurements in 31 post operative patients of mandible fracture who underwent open reduction and internal fixation for mandible fracture by locking miniplates . Following conclusions were drawn:

1. Bite force improvement was seen in all types of mandible fractures irrespective of the site and type of fractures over a period of 2^{nd}, 4^{th} and 6^{th} week post operatively. This improvement was however not statistically significant.
2. Decresed time of injury to surgery resulted in improved bite force measurements. This improvement too was not statistically significant
3. A more extensive study over a longer duration of time would include more study subjects and hence may result in a better outcome.

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S.NO	NAME	MRD NO	AGE	Age group	SEX	MODE OF INJURY	ORAL BLEED	COMORBIDITIES	MOBILITY	No. of factures	DIAGNOSIS	PARASYMPHYSIS	BODY	ANGLE	SUBCONDYLAR	INTERVAL -DATE OF INJURY TO SURGERY	APPROACH	PLATING
1	SK	570077	40	2	F	RSA	PRESENT	NIL	YES	3	BL PARSYMPHISIS,RT SUBCONDYLAR	1	0	0	1	2	INTRAORAL	BL DOUBLE 4 HOLE PLATE
2	LS	559978	29	1	M	RSA	ABSENT	NIL	NO	1	RT PARASYMPHYSIS	1	0	0	0	1	INTRAORAL	4 HOLE PLATE WITH GAP
3	NS	489553	38	2	M	RSA	ABSENT	NIL	NO	2	BL PARASYMPHYSIS	1	0	0	0	3	INTRAORAL	TWO 4 HOLE PLATE WITH GAP
4	GS	547899	42	3	M	RSA	ABSENT	NIL	NO	1	LT BODY OF MANDIBLE	0	1	0	0	4	INTRAORAL	TWO 4 HOLE PLATE WITH GAP
5	CS	534582	47	3	M	ASSAULT	ABSENT	HEPATITIS C	YES	1	LT PARASYMPHYSIS	1	0	0	0	2	INTRAORAL	TWO 4 HOLE PLATE WITHOUT GAP
6	TS	538339	48	3	M	RSA	PRESENT	NIL	NO	1	LT PARASYMPHYSIS	1	0	0	0	2	INTRAORAL	TWO 4 HOLE PLATE WITH GAP
7	RC	530517	45	3	M	FALL	ABSENT	NIL	YES	2	RT PARASYMPHYSIS,LT BODY	1	1	0	0	2	INTRAORAL	TWO 4 HOLE PLATE WITH GAP ON BOTH SIDES
8	N	521269	26	1	M	RSA	PRESENT	NIL	NO	2	RT ANGLE ,LT PARASYMPHYSIS	1	0	1	0	2	EXTRAORAL	TWO 4 HOLE PLATE WITH GAP ON BOTH SIDES
9	KK	512249	26	1	F	RSA	ABSENT	NIL	NO	2	RT PARSYMPHYSIS, LT ANGLE	1	0	1	0	1	EXTRAORAL	TWO 4 HOLE PLATE WITHOUT GAP,ANGLE NOT FIXED
10	MS	495307	30	1	M	ASSAULT	PRESENT	NIL	NO	1	LT ANGLE	0	0	1	0	3	EXTRAORAL	LONG PLATE
11	HK	471521	32	2	F	RSA	ABSENT	NIL	NO	2	RT PARASYMPHYSIS,LT BODY	1	1	0	0	2	INTRAORAL	TWO 4 HOLE PLATE WITH GAP
12	JS	641022	44	3	M	RSA	ABSENT	NIL	NO	1	RT PARASYMPHYSIS	1	0	0	0	4	INTRAORAL	4 AND 3 HOLE PLATE WITH GAP
13	N	609863	21	1	M	RSA	ABSENT	NIL	YES	2	BL PARASYMPHYSIS	1	0	0	0	3	INTRAORAL	BL 4 HOLE AND 3 HOLE PLATE
14	PS	649028	38	2	M	RSA	PRESENT	NIL	YES	1	RT BODY OF MANDIBLE	0	1	0	0	2	INTRAORAL	4 HOLE PLATE WITH GAP
15	GS	502869	40	2	M	RSA	ABSENT	NIL	NO	2	BL PARASYMPHYSIS	1	0	0	0	2	INTRAORAL	4 HOLE PLATE WITH GAP
16	HK	722818	33	2	F	RSA	ABSENT	NIL	NO	2	BL PARASYMPHYSIS	1	0	0	0	2	INTRAORAL	6 HOLE PLATE WITH GAP,CURVED PLATE
17	JS	510658	34	2	M	RSA	ABSENT	NIL	NO	1	LT PARASYMPHYSIS	1	0	0	0	1	INTRAORAL	TWO 4 HOLE PLATE WITH GAP
18	SS	489110	21	1	M	RSA	ABSENT	NIL	YES	2	BL PARASYMPHYSIS C SEGMENT	1	0	0	0	1	INTRAORAL	BL 4 HOLE PLATE WITH GAP
19	R	529194	28	1	M	RSA	ABSENT	NIL	NO	3	LT PARASYMPHYSIS, BL SUB CONDYLE	1	0	0	1	1	INTRAORAL	4 AND 3 HOLE PLATE WITH GAP
20	GS	524838	25	1	M	ASSAULT	PRESENT	HEPATITIS C	NO	2	BL PARASYMPHYSIS C SEGMENT	1	0	0	0	1	INTRAORAL	BL 4 HOLE PLATE WITH GAP
21	I	531400	36	2	M	FALL	ABSENT	NIL	NO	1	LT PARASYMPHYSIS	1	0	0	0	2	INTRAORAL	4 AND 3 HOLE PLATE WITH GAP
22	F	611679	29	1	M	RSA	ABSENT	NIL	NO	2	RT PARASYMPHYSIS, LT SUB CONDYLE	1	0	0	1	1	INTRAORAL	TWO 3 HOLE PLATE WITHOUT GAP WITH MMF
23	PJ	626869	28	1	M	RSA	ABSENT	NIL	NO	1	RT BODY OF MANDIBLE	0	1	0	0	1	INTRAORAL	TWO 4 HOLE PLATE WITH GAP
24	RK	635540	24	1	M	RSA	ABSENT	NIL	YES	2	RT PARSYMPHYSIS, LT ANGLE	1	0	1	0	2	EXTRAORAL	TWO 4 HOLE PLATE WITH GAP,ANGLE TWO 3 HOLE
25	HS	641120	20	1	M	RSA	ABSENT	NIL	YES	3	BL PARASYMPHYSIS, BL SUB CONDYLE	1	0	0	1	2	INTRAORAL	BL 4 HOLE PLATE WITH GAP WITH MMF
26	JS	651725	42	3	M	RSA	ABSENT	NIL	YES	1	RT PARASYMPHYSIS	1	0	0	0	2	INTRAORAL	TWO 4 HOLE PLATE WITH GAP
27	AS	672834	35	2	M	RSA	ABSENT	NIL	YES	1	LT BODY OF MANDIBLE	0	1	0	0	1	EXTRAORAL	4 HOLE PLATE WITH GAP
28	KS	679585	47	3	M	RSA	ABSENT	NIL	YES	3	LT PARASYMPHYSIS, BL SUB CONDYLE	1	0	0	1	1	INTRAORAL	4 AND 3 HOLE PLATE WITH GAP WITH MMF
29	RS	714924	33	2	M	RSA	PRESENT	NIL	YES	1	SYMPHYSIS MANDIBLE	1	0	0	0	1	INTRAORAL	TWO 4 HOLE PLATE WITH GAP
30	RM	748583	25	1	M	RSA	PRESENT	NIL	YES	3	BL PARASYMPHYSIS,LT SUB CONDYLE	1	0	0	1	2	INTRAORAL	BL TWO 4 HOLE PLATE WITH GAP WITH MMF
31	BL	764355	38	2	M	RSA	ABSENT	NIL	YES	1	LT PARASYMPHYSIS	1	0	0	0	2	INTRAORAL	3 AND 4 HOLE PLATE WITH GAP

S.NO	NAME	MRD NO	AGE	POST OP MMF	POST OP PAIN	POST OP CHEWING	COMPLICATION	BITE FORCE 2R	BITE FORCE 2L	BITE FORCE 4R	BITE FORCE 4L	BITE FORCE 6R	BITE FORCE 6L	Difference at 4week R	Difference at 4week L	Difference at 6week R	Difference at 6week L
1	SK	570077	40	DONE	4	5	PARESTHESIA	132	138	170	168	201	206	28.79	21.7	52.3	49.28
2	LS	559978	29	NOT DONE	3	4	SSI	129	128	165	172	192	196	27.91	34.4	48.8	53.13
3	NS	489553	38	DONE	4	5	PARESTHESIA	136	136	159	154	191	196	16.91	13.2	40.4	44.12
4	GS	547899	42	DONE	3	5	NIL	141	143	160	164	206	209	13.48	14.7	46.1	46.15
5	CS	534582	47	NOT DONE	3	5	NIL	139	139	161	168	199	191	15.83	20.9	43.2	37.41
6	TS	538339	48	NOT DONE	2	5	NIL	136	132	171	170	204	200	25.74	28.8	50.0	51.52
7	RC	530517	45	DONE	4	5	PARESTHESIA	139	136	176	181	193	196	26.62	33.1	38.8	44.12
8	N	521269	26	DONE	4	5	NIL	140	132	164	158	200	202	17.14	19.7	42.9	53.03
9	KK	512249	26	DONE	5	5	NIL	134	136	160	167	198	191	19.40	22.8	47.8	40.44
10	MS	495307	30	DONE	2	5	NIL	141	135	158	157	190	194	12.06	16.3	34.8	43.70
11	HK	471521	32	DONE	3	5	MALOCCLUSION	125	121	153	158	179	176	22.40	30.6	43.2	45.45
12	JS	641022	44	NOT DONE	2	5	NIL	139	138	162	159	195	193	16.55	15.2	40.3	39.86
13	N	609863	21	DONE	4	5	NIL	137	130	165	165	196	197	20.44	26.9	43.1	51.54
14	PS	649028	38	DONE	3	4	NIL	134	136	174	171	193	189	29.85	25.7	44.0	38.97
15	GS	502869	40	NOT DONE	4	4	NIL	129	127	157	155	189	187	21.71	22.0	46.5	47.24
16	HK	722818	33	NOT DONE	4	5	NIL	136	132	155	158	184	186	13.97	19.7	35.3	40.91
17	JS	510658	34	DONE	2	4	NIL	139	140	178	182	206	201	28.06	30.0	48.2	43.57
18	SS	489110	21	NOT DONE	3	5	PARESTHESIA	139	133	179	173	195	191	28.78	30.1	40.3	43.61
19	R	529194	28	DONE	3	5	NIL	128	132	159	153	186	182	24.22	15.9	45.3	37.88
20	GS	524838	25	NOT DONE	4	5	NIL	131	127	160	158	189	188	22.14	24.4	44.3	48.03
21	I	531400	36	DONE	3	5	NIL	136	138	152	154	190	191	11.76	11.6	39.7	38.41
22	F	611679	29	DONE	4	5	NIL	142	137	169	170	198	195	19.01	24.1	39.4	42.34
23	PJ	626869	28	NOT DONE	5	3	SSI	134	138	170	171	204	206	26.87	23.9	52.2	49.28
24	RK	635540	24	DONE	4	4	NIL	142	132	178	176	199	196	25.35	33.3	40.1	48.48
25	HS	641120	20	DONE	4	4	NIL	136	135	173	178	197	194	27.21	31.9	44.9	43.70
26	JS	651725	42	NOT DONE	3	5	NIL	135	131	160	163	193	196	18.52	24.4	43.0	49.62
27	AS	672834	35	DONE	2	5	NIL	129	133	168	164	189	191	30.23	23.3	46.5	43.61
28	KS	679585	47	DONE	3	5	NIL	134	128	153	160	188	184	14.18	25.0	40.3	43.75
29	RS	714924	33	NOT DONE	2	5	NIL	129	130	158	150	181	181	22.48	15.4	40.3	39.23
30	RM	748583	25	DONE	4	5	MALOCCLUSION	121	120	148	145	171	176	22.31	20.8	41.3	46.67
31	BL	764355	38	NOT DONE	3	5	NIL	126	129	169	171	190	191	34.13	32.6	50.8	48.06

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The Principal,
DMC, Ludhiana.

Subject: **Approval of Plan of Thesis.**

This is to inform you that the Faculty of Medical Sciences in its meeting held on 31.08.2018 has approved the plan of thesis of Soheb Rafique, a student of your college for MCh Plastic & Reconstructive Surgery along with the names of Supervisor/Co-Supervisor as under:-

Topic Plan of Thesis
Bite force measurements in patients treated for mandibular fractures

Supervisor
Dr. Sanjeev K. Uppal
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Co-Supervisor
Dr. Ramneesh Garg
Assoc. Prof.,
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The student has to submit the four copies of thesis, to the Controller of Examinations, BFUHS, Faridkot, at least six months before the commencement of theory examination, if he/she is otherwise eligible to take the examination. He /She must directed to attach a photocopy of this letter with the forwarding letter while submitting thesis to the University along with the letter of approval of University for change of supervisor/Co-Supervisor, change of topic,(if any).

SP Singh

Dr. S P Singh MS(Oph)
Controller of Examinations

Note :

1. *If any discrepancy found regarding topic of thesis or Supervisor/Co-Supervisor, inform undersigned within one month after issue of this letter.*
2. *The student may submit the thesis as per the schedule already conveyed i.e for May/June examination 30th Nov of the preceding the year of examination and for Nov/Dec examinations 31st May of the year of examination.*

BITE FORCE MEASUREMENTS IN PATIENTS TREATED FOR MANDIBULAR FRACTURES

THESIS PROPOSAL

FOR APPROVAL OF SUBJECT OF THESIS TO BE SUBMITTED

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MCh

IN

PLASTIC SURGERY

OF THE

BABA FARID UNIVERSITY OF HEALTH SCIENCES

FARIDKOT

February, 2018

DR SOHEB RAFIQUE

DEPARTMENT OF PLASTIC SURGERY (SPECIALITY)

DAYANAND MEDICAL COLLEGE AND HOSPITAL

ABSTRACT OF PLAN OF THESIS

Title	BITE FORCE MEASUREMENTS IN PATIENTS TREATED FOR MANDIBULAR FRACTURES
For the degree of	MCh IN PLASTIC SURGERY
Name of the candidate	Dr Soheb Rafique
Supervisor	Dr Sanjeev Uppal, Professor & Head, Department of Plastic Surgery, DMCH, Ludhiana
Co-supervisor	Dr Rajnder Mittal, Professor, Department of Plastic Surgery, DMCH, Ludhiana Dr Ramneesh Garg, Associate Professor, Department of Plastic Surgery, DMCH, Ludhiana
Institution	Dayanand Medical College & Hospital, Ludhiana
University	Baba Farid University of Health Sciences, Faridkot

Introduction: when used in patients treated surgically for mandibular fractures, records of maximum occlusal forces act as excellent assessment criteria for restoration of skeletal architecture and repair and healing of masticatory soft tissues.

Aim of Study: This study aims to evaluate how various types of mandibular fractures affect masticatory function in terms of maximal bite force and to determine their rate of recovery

Materials & methods: All patients who will undergo open reduction and internal fixation for isolated mandibular fractures in the Department of Plastic Surgery from January 2018 to June 2019 will be included in the study. For analyzing the data patients will be divided into five groups depending on the type of fracture. The bite force will be expressed as a percentage of maximum bite force of healthy age matched controls.

Clinical Significance: This study is designed to assess the effect of various mandibular fractures on bite force and its period of recovery in various types of fractures after treatment.

Keywords: Mandibular fractures, bite force, Occlusal force.

(Signature)	(Signature)	(Signature)	(Signature)	(Signature)
Candidate	Co-supervisor	Co-supervisor	Supervisor	Principal

CERTIFICATE OF FACILITIES AVAILABLE

This is to certify that the facilities for work on the subject of thesis titled "**BITE FORCE MEASUREMENTS IN PATIENTS TREATED FOR MANDIBULAR FRACTURES"** exist in the Department of plastic surgery, DMCH Ludhiana and will be provided to the candidate. We will see that the data being included in the thesis are genuine and is collected by the candidate himself/herself under our supervision and guidance.

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APPROVAL PROFORMA
BY RESEARCH & ETHICAL COMMITTEE
DAYANAND MEDICAL COLLEGE & HOSPITAL, LUDHIANA

Name of candidate	Dr Soheb Rafique
Department	PLASTIC SURGERY
Topic of Thesis	BITE FORCE MEASUREMENTS IN PATIENTS TREATED FOR MANDIBULAR FRACTURES
Likely date of appearing in PG examination	JUNE 2020
Date of enrollment	21 October 2017
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1) Supervisor **2) Co-Supervisor**	Dr Sanjeev K Uppal Dr Rajinder Mittal Dr Ramneesh Garg
Signature of Members of Research Committee with Stamp	**Signature of Members of Ethics Committee with Stamp**
1. HOD Pharmacology	1. HOD Physiology
2. HOD Surgery	2. HOD Pathology
3. HOD Pathology	3. HOD Pharmacology
4. HOD Medicine	4. HOD SPM
5. Dean Academics	5. HOD Medicine
6. Vice Principal	6. HOD Surgery
	7. HOD Obst. & Gynae.
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	10. Dean Academics
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	12. Principal

Approved: Yes / No

Chairperson
Research Committee
Chairperson
Research Committee

Approved: Yes / ~~No~~

Chairperson
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Ethics Committee

BABA FARID UNIVERSITY OF HEALTH SCIENCES, FARIDKOT

PROFORMA FOR REGISTRATION OF SUBJECT FOR DISSERTATION

1	NAME OF THE CANDIDATE AND ADDRESS	Dr Soheb Rafique
2	NAME OF THE INSTITUTE	DAYANAND MEDICAL COLLEGE AND HOSPITAL
3	COURSE OF STUDY AND SUBJECT	MCh PLASTIC SURGERY
4	DATE OF ADMISSION OF COURSE	21 October 2017
5	TITLE OF THE TOPIC	BITE FORCE MEASUREMENTS IN PATIENTS TREATED FOR MANDIBULAR FRACTURES

6. BRIEF RESUME OF THE INTENDED WORK

6.1 NEED FOR THE STUDY

Masticatory function refers to the ability of a person to masticate or chew without pain or interference. The major determinants of masticatory function are the range of mandibular motion, occlusion, maximum occlusal forces, and the activity of masticatory muscles.[1] This function is affected in dentofacial abnormalities and in traumatic and pathological injuries to the jaws. Fractures of the mandible not only cause a change in the skeletal architecture but also lead to changes in the other components of the masticatory apparatus.

Surgical treatment of mandibular fractures aims at restoration of skeletal form of the mandible with a hope that normal function and esthetics would be restored. In the process of any such surgical treatment, the resultant soft tissue injury in the form of stripping of masticatory muscles and iatrogenic neurovascular injury can further affect the masticatory apparatus. Although occlusal position can be restored surgically, it is unknown whether the patient might be able to produce occlusal loads, secondary to the changes in hard and soft tissue components of the masticatory apparatus either due to the fracture and/or its surgical treatment.[2] A person with a complete dentition and good occlusal relationship will probably demonstrate better masticatory performance than someone with fewer occlusal contacts. Likewise, someone who generates higher force during mastication might have a better masticatory performance.

Forces applied by the masticatory muscles in dental occlusion (i.e., bite force) following treatment of mandibular fractures have received little attention.

Maximum occlusal forces are an important and a significant parameter of masticatory function and also are relatively easy to measure and analyze.[3]

The amount of forces used during functional activity (functional bite forces) is probably much less but it is not possible at present to measure the functional bite forces. Thus, when used in patients treated surgically for mandibular fractures, records of maximum occlusal forces act as excellent assessment criteria for restoration of skeletal architecture and repair and healing of masticatory soft tissues.

Since the biting force is an important parameter in assessing the masticatory function, this study is designed to assess the effect of various mandibular fractures on bite force and its period of recovery in various types of fractures after treatment. This study aims to evaluate how various types of mandibular fractures affect masticatory function in terms of maximal bite force and to determine their rate of recovery.

6.2 REVIEW OF LITERATURE

The sheer pace of modern life with high speed travel as well as an increasingly violent and intolerant society have made facial trauma a form of social disease from which no one is immune. With the growth in the Indian economy in the recent past, the traffic density on the roads has increased much more than earlier. According to the estimates of Association of Automobile Manufacturers of India the number of automobiles on the road has grown more than tenfold during the last 10 years. This growing number of automobiles on the road has result in an increase in number of road traffic accidents and maxillofacial injuries.

Trauma to the facial region frequently results in injury to soft tissues, teeth, and major skeletal components of the face, including the mandible, maxilla, zygoma, naso-orbital-ethmoid complex, or supra orbital structures. Participation in the management and rehabilitation of the patients with facial trauma involves a thorough understanding of the types of principles of evaluation for and surgical treatment of facial injuries. Whenever facial structures are injured, the goal of the treatment must be maximal rehabilitation of the patient.[4]

Oikarinen and Lindqvist studied 729 patients with multiple injuries sustained in RTA. The most common facial fractures were in mandible (61%) followed by maxilla(46%), zygoma(27%) and nasal bone(19%). Fractures of the mandible alone account for a large proportion (70%) of all facial injuries [4] because of the mandible's prominence and relative lack of support. The incidence of mandibular fractures was more commonly in age group 20–30 years (60%).

The treatment of mandibular fractures has been in a constant state of evolution with goals to restore function and premorbid occlusion. Guglielmo Salicetti in 1492 [5] introduced the concept of maxillomandibular fixation, which was later popularized by Gilmer in 1887.[6] The concept of open reduction for fractures of the mandible was introduced by Buck [7] using an iron loop, followed by Gilmer [8] and Luhr.[9] Champy et al described a novel and currently the most accepted concept of using noncompression monocortical plates in the regions, referred to as "Champy's lines of osteosynthesis."[10]

Because of the importance of the mandible as vital component of the masticatory apparatus, such injuries can be expected to significantly alter occlusion, mandibular range of motion, muscle activity levels, and occlusal forces.[11]

Bite force is one indicator of the functional state of the masticatory system that results from the action of jaw elevator muscles modified by the craniomandibular biomechanics.[12] The bite force measurements can be made directly by using a suitable transducer that has been placed between a pair of teeth. This direct method of force assessment appears to be a convenient way of assessing the submaximal force. An alternative method is indirect evaluation of the bite force by employing the other physiologic variables known to be functionally related to the force production.[13] Electromyographic activity of the surface elevator muscles of the mandible can be picked up from the cutaneous projection of the muscular belly.[14] In this way, obtained data give an idea for the bite force. The results of some investigations showed a linear relationship between electromyographic activity

potentials and direct bite force measurements, especially at a submaximal level.[13]

Therefore, bite force measurements are excellent assessment criteria for restoration of the skeletal architecture and the repair and healing of masticatory soft tissues.[3] Maximum voluntary bite force measurement in healthy adult may be in the order of 15.3 kPa in the incisor and 48.3 and 49.3 kPa in left and right molar regions respectively.

The significant reduction of bite forces following treatment of fracture mandible might be explained by traumatic or operative trauma to the muscle of mastication or to protective neuromuscular mechanisms of the masticatory system.[15] Furthermore, the patient's willingness to bite hard is also a major factor.

Teenier et al [16] studied the effects of local anesthesia on bite force generation and electromyographic activity, showing that there were no significant differences in the bite forces observed between the anesthetized and nonanesthetized sides, nor on the anesthetized side at different levels of anesthesia. They concluded that sensory information from the dentition and surrounding periodontium are not critical for modulating maximal bite forces or in recruitment of jaw muscles to generate maximal voluntary bite forces.

Dean [17] performed a preliminary study of maximum voluntary bite force and jaw muscle efficacy in 84 patients who underwent orthognathic surgery for various dentofacial deformities and concluded that there was a reduced ability to generate occlusal forces in patients before surgery. A reduction in maximal occlusal force also attributed to reduced efficiency of jaw muscles.

Dal Santo et al [18] stated that molar bite force on the fractured side in zygomatic complex fractures was significantly less than that on the unaffected side. They suggested that molar bite force was significantly less in patients as compared with the control group for several weeks after surgery.

Tate et al [19] did a study for measurement of bite forces in patients treated for mandibular angle fractures. Their study suggested that molar bite force was significantly less in patients till postoperative week 6.

Gerlach and Schwarz [15] measured bite forces in patients for mandibular angle fractures treated with miniplate osteosynthesis through an intraoral approach with a single miniplate at the external oblique line of the mandible without postoperative maxillomandibular fixation. The study concluded that at postoperative week 1, only 31% of the maximal vertical loading found in the control group was registered, and these values increased to 58% at postoperative week 6.

In a study by Kshirsagar [20] revealed that the maximum voluntary bite force measurement in healthy Indian individuals is of the order of 36 kg in the molar region and 15 kg in the incisor region. Females showed reduced bite forces when compared with males in similar age groups. In cases of parasymphyseal fractures, bite forces were subnormal till 4 weeks, and maximum bite forces were restored by the 8 weeks. There was no significant gain in bite forces after 8 weeks.

A study by Sybil [21] conclude that mandible fractures adversely affect maximum bite forces, although temporarily. Fractures of the condylar region have a stronger influence on the bite forces than fractures at other sites of the mandible. These fractures also take a longer time for normalization. This was

followed by the fractures of the angle of mandible, which take comparatively less time for normalization with respect to maximum bite forces. Fractures in any other region of the mandible have a weaker influence on the bite forces and also reach normal values faster.

6.3AIMS AND OBJECTIVES

The aim of this study will be to assess the magnitude of damage of the masticatory system caused by mandibular fractures and their rate of recovery by measuring maximum bite forces.

7.0MATERIALS AND METHODS

7.1 Source of Data

All patients attending the Emergency or OPD at Dayanand Medical College and Hospital Ludhiana, willing to be a part of the study will be included in the study.

INCLUSION CRITERIA

All patients who will undergo open reduction and internal fixation for isolated mandibular fractures in the Department of Plastic Surgery from January 2018 to June 2019 will be included in the study.

EXCLUSION CRITERIA

(1) Patients with associated mid-face fractures,

(2) Edentulous patients,

(3) Patients below 14 and above 45 years of age,

(4) Neurosurgically compromised patients.

Bite forces will be measured between occluding molar teeth using a pressure sensor (customized bite force machine). Each patient will be asked to sit erect with a relaxed head posture, keeping the Frankfurt horizontal plane parallel to the floor. Patients will be asked to bite on the prescal paper for 5 second and scan interpreted by software. The largest value will be chosen as the maximum bite force. The bite forces will be recorded at three occasions—second, fourth, sixth, postoperative weeks.

For analyzing the data patients will be divided into five groups. Group I will include patients with isolated angle fractures. Group II will include patients with fractures of unilateral angle and ipsilateral or contralateral parasymphysis. Group III will include patients with fractures of isolated

parasymphysis. Group IV will include patients with fractures of unilateral parasymphysis and ipsilateral or contralateral condylar complex. Group V will include patients with fractures in more than two sites in the mandible. Bite force measurements of the patients were compared with those of age, sex, and weight-matched controls. The bite force measurement of the control will be considered as the desired maximum bite force measurement for the corresponding patient. The observations were statistically analyzed using the student's unpaired t-test.

DURATION OF STUDY:

18 months (January 2018 to June 2019)

OUTCOME

The bite forces will be recorded at three occasions—first, fourth, sixth, postoperative weeks. The value will be expressed as a percentage of normal bite force of age matched controls.

STATISTICAL ANALYSIS

Data will be described in terms of range; mean ±standard deviation (± SD), median, frequencies (numberof cases) and relative frequencies (percentages) as appropriate. For comparing categorical data, Chi square ($\chi 2$) test will be performed and exact test will be used when the expected frequency is less than 5. Comparison of quantitative variables between the variables will be done using ANOVA. A probability value (*p* value) less than 0.05 will be considered statistically significant. All statistical calculations will be done using SPSS (Statistical Package for the Social Science)SPSS 17 version statistical program for Microsoft Windows

7.3 DOES THE STUDY REQUIRE ANY INVESTIGATIONS OR INTERVENTIONS TO BE CONDUCTED ON PATIENTS OR OTHER HUMANS OR ANIMALS? IF SO, PLEASE DESCRIBE BRIEFLY

Yes, ORIF (open reduction and internal fixation)

CT face with 3D reconstruction

7.4 HAS ETHICAL CLEARENCE BEEN OBTAINED FROM YOUR INSTITUTION IN CASE OF 7.3?

Attached herewith.

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PROFORMA

S. No. MRD No.

NAME AGE/SEX

FATHER'S/HUSBAND'S NAME

CHIEF COMPLAINT

HISTORY OF PRESENT ILLNESS:

PAST HISTORY

H/O allergy

Associated Illness

LOCAL EXAMINATION:

CT FINDINGS:

TYPE OF FRACURE: DISPLACED/UNDISPLACED

SURGERY EXECUTED:

NEED FOR INTERMAXILLARY FIXATION:

APPROACH: (TRANSBUCCAL/ INTRAORAL)

INTRA OP FINDINGS:

IMPLANT USED: TYPE: NUMBER OF IMPLANTS

Signature of candidate ***Signature of supervisor***

	Post operative Week 2	Post operative week 4	Post operative week 6
NEUROSENSORY EVALUATION			
Light touch			
Brush Directional strokes			
OCCLUSAL DISCREPANCIES			
Normal			
Moderate			
Gross			
POST OPERATIVE PAIN			
Visual analogue scale			
POST OPERATIVE CHEWING			
Visual analogue scale			
POST OPERATIVE COMPLICATIONS			
BITE FORCE MEASUREMENT			

Signature of candidate ***Signature of supervisor***

CONSENT FORM

I _____ S/o _____ have been fully explained about the study "BITE FORCE MEASUREMENTS IN PATIENTS TREATED FOR MANDIBULAR FRACTURES". I have also been told fully about the methodology and purpose of the study in vernacular language.

I hereby give my consent to participate in the study knowing that no extra cost will be borne by me merely to be part of the thesis, and the study is for the advancement of medical knowledge and betterment of mankind.

I also affirm that my consent to participate in the study is without any inducement or coercion. I reserve the right to opt out of the study at anytime I decide to do so.

I understand that the confidentiality of my identity shall be maintained at all times during and after the study.

Witness

Patient/ Attendant

_____

(Supervisor)

_____

(Candidate)

सहमति फार्म

मैं _____ बेटा/ बेटी _____

__ पूरी तरह से अध्ययन " BITE FORCE MEASUREMENTS IN PATIENTS TREATED FOR MANDIBULAR FRACTURES " के बारे में समझाया । मुझे पूरी तरह कार्यप्रणाली और प्राकृत भाषा में अध्ययन के उद्देश्य के बारे में कहा गया है।

मुझे बताया गया है कि मैं किसी भी अतिरिक्त लागत नहीं उठाना पड़ेगा। मेरे अध्ययन में भाग लेने की सहमति किसी लोभन या भय के बिना है। मैं अध्ययन के बाहर कभी भी मैं ऐसा करने का फैसला में चुनते करने का अधिकार सुरक्षित रखते हैं। मैं समझता हूँ कि मेरी पहचान की गोपनीयता के अध्ययन के दौरान हर समय बनाए रखा जाएगा।

गवाह

रोगी / परिचर

_____ _____

(पर्यवेक्षक) (उम्मीदवार)

ਸੋਹ੍ਮਤੀ ਪਤ੍ਰ

ਮੈਂ _____ ਪੁੱਤਰ / ਪੁੱਤਰੀ _____ ਇਹ ਸੋਹ੍ਮਤੀ ਕਰਦਾ ਹਾਂ ਕੇ ਮੈਨੂ "BITE FORCE MEASUREMENTS IN PATIENTS TREATED FOR MANDIBULAR FRACTURES" ਤੇ ਕੀਤੀ ਜਾ ਰਹੀ ਖੋਜ ਦਾ ਹਿੱਸਾ ਬਣਨ ਵਿਚ ਕੋਈ ਹਿਚਕ ਨਹੀਂ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਬਾਰੇ ਸਬ ਕੁਛ ਪੰਜਾਬੀ ਵਿਚ ਸਾਫ਼ ਸਾਫ਼ ਦਸ ਦਿੱਤਾ ਗਿਆ ਹੈ।

ਇਸ ਕਰਕੇ ਮੈਂ ਇਸ ਕਾਜ ਦਾ ਹਿੱਸਾ ਬਣਨ ਲਈ ਪੂਰੀ ਤਰਹ ਸਹਿਮਤ ਹਾਂ । ਮੈਨੂ ਇਸ ਲਈ ਕੋਈ ਡਰਾਵਾ ਜਾਂ ਪ੍ਰਲੋਭਨ ਨਹੀਂ ਦਿੱਤਾ ਗਿਆ ।

ਮੈਂ ਇਹ੍ ਸਮਝਦਾ ਹਾਂ ਕੀ ਮੇਰੀ ਪੇਹ੍ਚਾਨ ਲੁਕਵੀਂ ਰਾਖੀ ਜਾਵੇਗੀ

ਗਵਾਹ

ਸੁਪ੍ਰੈਜ਼ੇਰ

ਰੋਗੀ / ਰਿਸ਼ਤੇਦਾਰ

ਖੋਜ ਕਰਤਾ